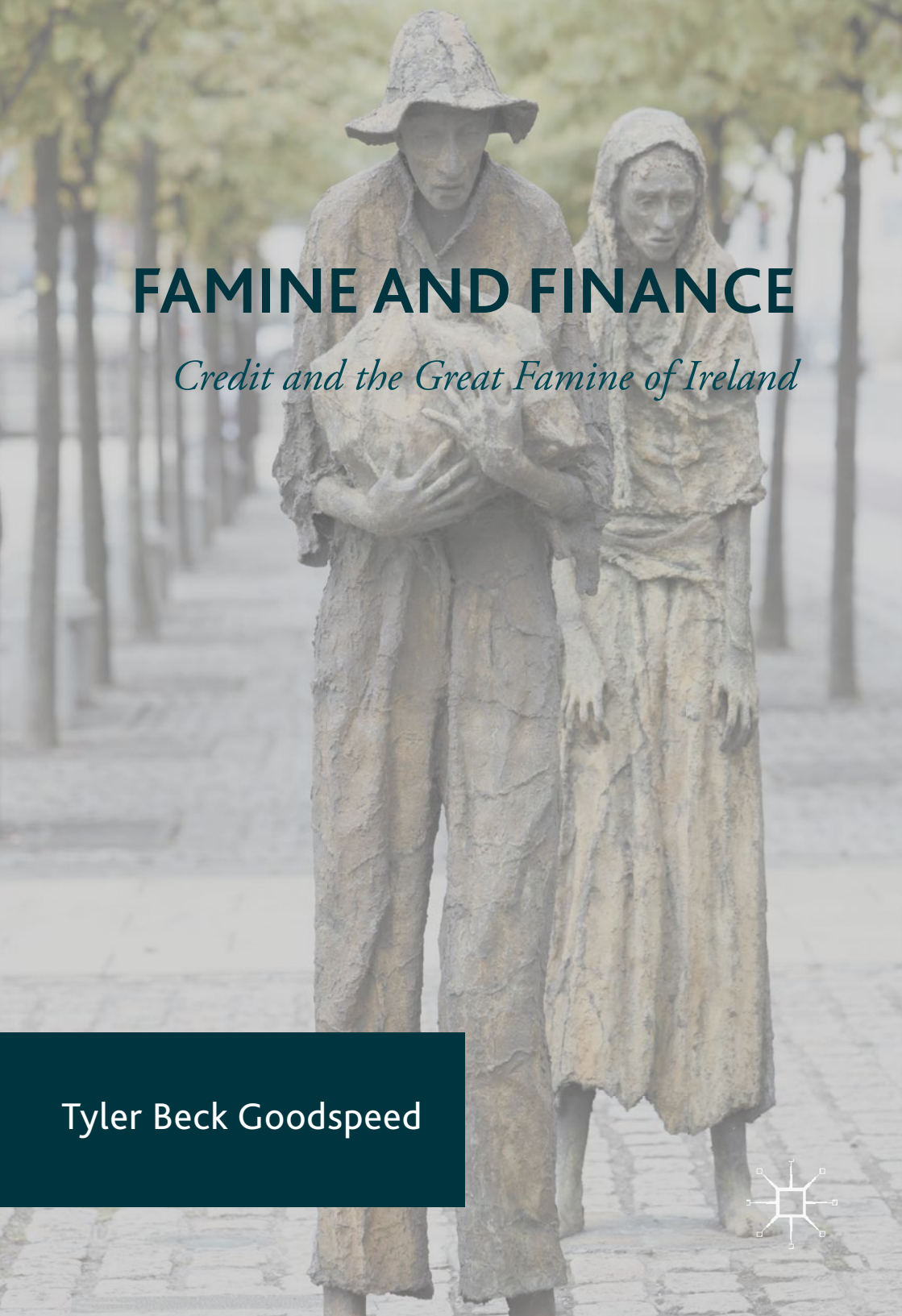

FAMINE AND FINANCE

Credit and the Great Famine of Ireland

Tyler Beck Goodspeed

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For the millions who went hungry

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1

Revisiting the Great Famine

> Ireland is now suffering under a circle of evils, producing and reproducing one another. *Want of capital* produces want of employment—want of employment, turbulence and misery—turbulence and misery, insecurity—insecurity prevents the introduction of capital—and so on. Until this circle is broken, the evils must continue, and probably augment. Report of George Nicholls on the Irish Poor Laws (1838)

The Great Irish Famine of 1845–1851 was the last major famine in Western European history. Claiming more than one million lives—one-eighth of Ireland's pre-famine population—the catastrophe ranks as one of the worst instances of mass starvation in modern history. Including the more than one million who emigrated between 1845 and 1851, the island's total population is estimated to have fallen by between 20% and 25%, and has never since returned to its pre-famine level. Without doubt, the primary short- and possibly long-run margin of adjustment to this severe environmental shock was a mass exodus of humanity, despite the fact that Ireland's soil remained some of the most fertile in the UK, its populace unvisited by war, and its climate unvisited by drought or extreme weather.

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Foremost among the lingering unanswered questions regarding the Great Famine, therefore, is why adjustments in land use failed to avert demographic catastrophe. *Phytophthora infestans*, the blight that devastated Ireland's potato crop, left wheat, oats, barley, flax, hay, straw, cattle, swine, sheep, and poultry untouched. And yet, while the Irish agricultural economy did gradually, over the subsequent three decades, reorient itself away from potato cultivation toward other forms of tillage and animal husbandry, this substitution was clearly not sufficiently extensive or rapid to prevent the deaths and emigration of some two million souls.

Though there were many factors that impeded Ireland's ability to absorb and adjust to a shock of the magnitude of potato blight, the central argument of this book is that an additional, thus far largely overlooked factor was an acute lack of access to capital markets among the bulk of Ireland's rural poor. On the eve of the famine, not a single Irish bank was in the business of extending loans smaller than £10, at a time when per capita income was roughly £10, and per capita income at the 67th percentile was about £4.30. Consequently, one of the few formal sources of credit to lower-income agricultural households were the Irish Loan Funds—privately run for-profit microfinance institutions (MFIs). Initially conceived by the Anglo-Irish essayist and pamphleteer Jonathan Swift, the Loan Funds operated on the standard microfinance model of extending small loans for very short terms, with weekly repayments, and cosignatories in lieu of collateral. As of 1843, there were 300 of these funds, active in 240 of 323 Irish baronies, extending half a million loans a year. My project therefore asks two primary questions—first, how marginal adjustments differed where the environmental shock was marginally more severe; and, second, how relative marginal adjustments differed where, controlling for the severity of the environmental shock, one binding constraint—namely, access to small loan credit—was at least partially relaxed.

To answer these questions, I use original archival sources—constabulary reports from the Parliamentary Famine Relief Commission—to construct a database of the severity of potato blight infection at the local level. I find that in the short run, districts more severely infected by blight experienced larger population declines and accumulations of buffer livestock by small- and medium-sized farms, while in the medium and long runs, worse affected districts experienced greater substitutions toward other tillage crops and grazing livestock, particularly by medium-sized farms.

I further find that access to microfinance credit from the Loan Funds was an important factor in facilitating non-demographic adjustment to blight; worse affected districts with at least one microfinance fund during the famine experienced substantially smaller relative population declines and larger increases in buffer livestock during and immediately after the famine, and greater medium- and long-run relative substitutions toward other crops and grazing livestock, than worse affected districts without a fund. More specifically, I find that the presence of at least one Loan Fund in a severely infected district during the famine was associated with a 3660-person smaller relative population decline by 1851. By 1852, farms under 15 acres in severely infected districts with a Loan Fund had increased pig and poultry holdings by £673.23 more than farms under 15 acres in districts without a fund, relative to comparably sized farms in moderately affected districts, and had furthermore reduced the potato's share of total tillage acreage by an additional 29.3 percentage points.

Revisiting a salient question in the economic history literature on the Great Famine, results presented in Chap. 5, "Was Malthus Right," are generally inconsistent with a predominantly Malthusian account of the Irish Famine. That is, controlling for the severity of blight infection, access to microfinance credit, regional time fixed effects, and spatial fixed effects, while higher adult literacy was associated with smaller relative population declines in worse affected districts, other traditional proxy "Malthusian" variables do not appear to have been associated with differential demographic changes in worse affected districts, relative to less severely affected districts. Specifically, the cumulative population decline, relative to low-blight districts, was still statistically no different in high- and medium-blight districts with higher pre-famine population density, potato dependence, baronial valuations, and fourth-class housing stock versus high- and medium-blight baronies with lower pre-famine population density, potato dependence, baronial valuations, and fourth-class housing stock.

Results do, however, suggest that variation in pre-famine Malthusian pressures was associated with modest differential relative adjustments in land use and livestock acquisition and disposal, particularly over the medium to long runs. While greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were associated, in the short run, with greater acreage allocation toward the potato in worse affected districts, over the medium and long runs, worse affected districts

with higher pre-famine potato dependence and fourth-class housing substituted crop acreage away from potato cultivation. Specifically, after the first year of blight, high- and medium-blight districts with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively increased the fraction of tillage acreage allocated to the potato crop by 0.014 and 0.017 percentage points more, respectively, than high- and medium-blight districts with a 1-percentage point lower potato crop acreage allocation. By 1856, however, high- and medium-blight districts with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively reduced the fraction of tillage acreage allocated to the potato crop by 0.038 percentage points more than high- and medium-blight districts with a 1-percentage point lower potato crop acreage allocation.

Similarly, after the first year of blight, high- and medium-blight districts with houses rated "fourth class" accounting for a 1-percentage point greater share of total housing stock relatively increased the fraction of tillage acreage allocated to the potato crop by 0.007- and 0.006 percentage points more, respectively, than high- and medium-blight districts with a 1-percentage point lower fourth-class share of total housing. By 1856, however, high- and medium-blight districts with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively reduced the fraction of tillage acreage allocated to the potato crop by 0.011 and 0.014 percentage points more, respectively, than high- and medium-blight districts with a 1-percentage point lower fourth-class share of total housing.

Parallel to adjustments in crop acreage allocation, greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were also associated with differential changes in livestock assets among farms under 15 acres in worse affected districts. In the short through medium runs, farms under 15 acres in worse affected districts with higher pre-famine potato dependence and fourth-class housing stock, relative to equivalently sized farms in low-blight districts, increased stocks of buffer livestock holdings of chickens and pigs, compared to farms under 15 acres in worse affected districts with lower potato dependence and fourth-class housing stock. These relative accumulations, however, dissipated over the very long run. Greater pre-famine potato dependence and fourth-class housing stock were, moreover, associated with greater short-run liquidations of grazing livestock assets by farms

under 15 acres in worse affected districts. Higher pre-famine population density and valuations, meanwhile, were associated with greater long-run relative accumulations of buffer livestock by farms under 15 acres in worse affected districts, in tandem with no long-run relative reduction in acreage allocation to the potato in more demographically dense districts and, indeed, a long-run relative reallocation toward the potato crop in districts with higher pre-famine valuations.

Building on Hornbeck (2012), which focuses on margins of adjustment in a more developed economy context and does not explore the possible effects of constrained credit on the time-path of adjustment in great depth, the results of this book demonstrate that access to credit plays an important role in short- and medium-run adjustments to adverse environmental shocks in a subsistence economy. The long-run non-demographic adaptations to the arrival of blight in Ireland, specifically crop portfolio diversification and substitutions away from tillage toward pasture, were effected earlier and to a greater extent in worse affected districts with a microcredit lender versus in those without. Moreover, in the presence of incomplete capital markets, access to microcredit appears to have allowed farmers to acquire temporary stocks of relatively cheap, liquid buffer livestock assets with low, but also low volatility, yields. This is significant because while recent research has demonstrated that access to microfinance credit can mitigate the impact of environmental shocks on income and consumption (Dercon 2002), most microfinance studies have focused on welfare effects and optimal models of sustainability under relatively ordinary lending circumstances.

An important feature of agricultural economies with incomplete markets is that short-run adjustments to adverse production shocks are often impeded by binding constraints that may be relaxed only over the long run (Swinton 1988; de Janvry et al. 1991; Besley and Case 1993; Foster and Rosenzweig 1995; Conley and Udry 2010). In particular, uncertainty, as well as capital and land constraints, can result in demographic change constituting the primary short-run margin of adjustment (Rosenzweig and Stark 1989; Townsend 1994; Udry 1994; Dercon 1996; Fafchamps et al. 1998; Munshi 2004). Research has also demonstrated that production shocks in the form of adverse environmental change are especially harmful to developing economies and their poorest populations, with the threat likely to intensify (Jayachandran 2006; World Bank 2009;

Dell et al. 2012). Thus, while recent studies have analyzed economic adaptation to environmental change in more developed settings, it is increasingly important to understand such adjustment in developing contexts (Deschenes and Greenstone 2007; Hornbeck 2012). Historical episodes provide a unique opportunity to analyze both short- and (very) long-run adaptations to environmental shocks than is possible in more contemporary studies (Reardon et al. 1992; Gine and Klonner 2005; Kazianga and Udry 2006; Duflo et al. 2008). Moreover, as the distribution of adjustment to a large shock along different economic margins may vary considerably depending on the relevant time horizon, it is critical to examine such responses with a long historical perspective (Lange et al. 2009).

Second, this study contributes to the extant literature on the debated role of livestock in smoothing consumption in developing contexts. While Rosenzweig and Wolpin (1993) and Verpoorten (2009) provide evidence for the use of bullocks by credit-constrained households in rural India and Rwanda as buffer stocks for consumption, Fafchamps et al. (1998) find that livestock sales in Burkina Faso compensated for only 30% of income shortfalls due to adverse rainfall shocks, and Kazianga and Udry (2006) find little evidence of consumption smoothing. The results of this study, however, suggest that in analyzing the role of buffer livestock in consumption smoothing, it is important to distinguish between different types of livestock and their respective purposes for different types of farmers. Moreover, results indicate that the importance of buffer livestock may lie not so much in their liquidation value in the event of income shortfalls, as is typically reckoned, but rather in the hedging value of a low but relatively reliable supplemental income stream, for example, through the sale of eggs from poultry stocks.

In addition, because MFIs are often vulnerable to spatially correlated shocks such as adverse environmental change, I also analyze the effects of the Great Famine on the Irish Loan Funds themselves, exploring which management and lending practices allowed some Loan Funds to survive the famine while others failed. A major potential challenge confronting microfinance lenders, cooperatives, and credit-granting non-governmental organizations is that they may be ill-equipped to absorb the kinds of large covariate shocks typical of agricultural loan portfolios (Binswanger and Rosenzweig 1986; Braverman and Guasch 1986; Rosenzweig 1988; Shoji 2010; Kurosaki and Khan 2012). While the results of this book,

along with other recent research, demonstrate that access to microfinance credit can mitigate the impact of environmental shocks on income and consumption (Dercon 2002; Khandker 2007; Becchetti and Castriota 2008), the ability of microfinance lenders to cope with large-scale aggregate shocks involving high spatial correlation in income effects and default risk remains understudied.

This is a significant gap in the extensive microfinance literature—which has tended to focus on welfare effects and optimal models of sustainability under ordinary lending circumstances—because the concentration of borrowers and depositors in contiguous geographic locales and identical crop portfolios can generate considerable covariate risk for MFIs, for example, following adverse environmental change (Miamidian et al. 2005). MFIs may therefore be most vulnerable where and when they are most needed (Berg and Schrader 2012). History offers a unique opportunity to observe such rare events, and to analyze differential MFI outcomes and adjustment strategies, over both the short and long runs, in order to identify how sustainable lending models may vary depending on the macro context.

Following Hollis and Sweetman (2004) and utilizing the dataset constructed for this book, in Chap. 4, I thus analyze the effects of the Great Famine on Loan Fund failure rates and balance sheet changes. I find that compared to funds operating in less infected districts, funds in districts worse affected by blight in 1845 and 1846 not only had lower predicted probabilities of survival and experienced greater declines in lending, capital, and depositors, but also experienced larger declines in average interest rates, penalty fines on loans, and bad debts. Borrowing costs for qualifying borrowers therefore fell as funds in worse affected districts contracted lending and significantly raised credit standards.

I further find that pre-famine balance sheet metrics were important predictors of institutional survival during the famine, though certain metrics that were generally associated with higher (lower) survival probabilities were associated with lower (higher) survival probabilities where the severity of the environmental shock was greater. Specifically, while greater leverage, lower average staff salaries, and more depositors were generally associated with higher predicted probabilities of institutional survival, the reverse was true where blight infection was more severe. Conversely, though a higher average pre-famine unit cost of credit intermediation was generally associated with a lower predicted survival

probability, in the face of severe blight infection, funds with higher expenses as a percentage of total lending before the famine were more likely to survive the first two years of blight.

Funds with higher pre-famine gross profit margins per loan were generally no more likely to survive over the long term than less profitable funds, but higher pre-famine margins were positive predictors of institutional survival where blight infection was worse. While ministers were generally less competent fund managers—funds managed by ministers had a significantly lower predicted probability of survival—ministers were statistically no more or less competent than non-clergy managers where the magnitude of the environmental shock was greater. Differences in average pre-famine loan size, bad debts, fines ratio, number of loans, and cost of capital do not appear to have had differential effects on predicted survival probabilities during and immediately after the famine, either generally or particularly where blight infection was more severe.

To explore potential channels through which differences in pre-famine balance sheet metrics influenced survival probabilities, I also examine whether certain balance sheet metrics were associated with differential institutional responses to the adverse shock. I find that balance sheet contraction and flight to quality were the primary mechanisms by which some Loan Funds managed to successfully navigate the famine, which suggests that one cost of credit market resilience to a major aggregate shock like adverse environmental change is reduced outreach to borrowers of lower credit quality. This result is consistent with my additional findings that while Loan Fund lending had significant effects on agricultural adaptation by small- to medium-sized Irish farms, it does not appear to have affected the very smallest and most vulnerable farms of under 1 acre.

Specifically, relative to funds with lower average gross profit margins per loan before the famine, funds in worse affected districts with higher pre-famine margins relatively reduced average loan size, interest rates, fines ratios, and bad debts during the famine, implying a relative increase in average credit quality among approved borrowers. Similarly, funds in worse affected districts with higher staff salaries before the famine relatively reduced their average annual number of loans and fines ratios during the famine.

Moreover, while funds with higher pre-famine profit margins experienced relative declines in average margin per loan, there was no

difference in their average, non-differenced level of profit margin per loan during the famine. In contrast, funds in worse affected districts with more depositors before the famine experienced relative increases in average loan size, fines ratios, and bad debts during the famine, while funds in worse affected districts that had been more highly levered before the famine experienced a relative rise in the unit cost of credit intermediation and relative decline in profitability, resulting in lower average margins per loan during the famine. In robustness checks, I find that differences in pre-famine balance sheet metrics cannot be explained by pre-famine differences in available micro-level social and economic variables.

These findings suggest that Loan Funds that had been earning higher rents before the famine had more scope to contract credit and raise lending standards in response to an adverse spatially correlated shock, while still remaining profitable. Better compensated staffs seem to have been more effective at restricting credit to higher-quality borrowers. By contrast, funds that had been relying more heavily on leverage appear to have been more severely affected by balance sheet contraction during the famine, with more levered funds experiencing relative increases in the unit cost of credit intermediation and relative decreases in average profit margin per loan, resulting in lower average margins during the famine. Funds with more depositors, meanwhile, seem to have been less able to contract their lending portfolios and raise average credit standards. These results imply that MFI sustainability in the face of a major covariate shock such as a natural disaster may depend critically on an ability to rapidly scale down lending, reduce average loan size, and significantly raise lending standards, and therefore that though microfinance may help to mitigate the effects of such shocks on borrowers of higher credit quality, it is not a viable mitigant for more vulnerable borrowers.

1.1 Historical Background

1.1.1 The Irish Loan Funds

On the eve of the Great Famine, Ireland's was an undercapitalized subsistence economy heavily dependent upon a single staple crop. By 1845, median farm size in many Irish districts had declined to such levels

that the potato was the only crop with sufficient yield and nutritional and caloric content to support an average-sized family for 12 months (Mokyr 1985; Bourke 1993; Ó Gráda 1995, 1999).[1] On the eve of the famine, the potato thus accounted for approximately 60% of the Irish food supply, with nearly 40% of Irish depending almost exclusively on the potato for subsistence (Bourke 1993). While average annual per capita income was an estimated £10, with those at the 67th percentile earning £4.30 or less, no conventional bank in Ireland was in the business of extending loans in amounts smaller than £10.[2] Indeed, before 1845, just two Irish joint-stock savings banks—the Agricultural and Commercial Bank and the Provident Bank—had ventured into the business of extending loans below £10; both had failed by 1845.

Registered pawnbrokers were legally entitled to grant loans at interest. Interest charged could not exceed one halfpenny per 2 shillings per month, corresponding to 5 shillings in the pound per annum, or 25%, though penalties on late payments could often raise effective annual rates to 40%. An 1849 registry counted just 477 of such entities for the entire island, however. Before 1850, moreover, there was just one Irish building society, established in Dublin in 1846. Unregistered moneylenders, so-called gombeen men (from the Irish Gaelic *gaimbín*, for money interest, from the Latin *cambium*, for exchange), meanwhile, extended loans at significantly higher rates, not uncommonly a shilling in the pound per week, corresponding to 520% simple interest, or 1200% compound interest, per annum (Keenan 2001).

Important providers of credit to Ireland's rural poor, therefore, were the Irish Loan Funds—privately-run microfinance funds operating throughout Ireland from the mid-eighteenth century into the early twentieth century. Originally conceived by Irish essayist and satirist Jonathan Swift in the early 1700s, the first Loan Fund was established as a quasi-charitable enterprise by the Musical Society of Dublin, which

[1] Despite high potato dependency, however, revisionist quantitative work by Mokyr (1985) and Ó Gráda (1995, 1999) challenges conventional claims that the pre-famine Irish economy was balanced on a Malthusian knife-edge. Mokyr and Ó Gráda find that, owing partly to the high caloric and nutritional content of the potato, mean height and estimated daily caloric intake were in fact higher in pre-famine Ireland than in most other Western European countries.

[2] Mokyr (1985) estimates annual per capita income was between £9.50 and £10.50, and per capita income at the 67th percentile between £4.30 and £4.60.

for a brief time thereafter operated a branch system of musical loan societies. By the early 1840s, however, the Loan Funds were a diverse set, including private pawnbrokers and Mont-de-Piétés that had reorganized and registered as Loan Funds, and with no operating connection to the original Dublin society (McLaughlin 2009).[3] On the eve of the famine, there were thus 300 independent Loan Funds active in more than half of Ireland's 323 baronies, extending almost 500,000 loans a year to approximately 300,000 borrowers.[4]

Like more contemporary microfinance models, the Irish Loan Fund model was predicated on extending small, short-term loans with frequent payments, secured by two cosignatories in lieu of collateral. The average fund made 1750 loans a year, with a mean loan size of approximately £3 and a fixed maximum of £10.[5] Standard term was 20 weeks, with mandatory weekly payments, enforced by penalty fines. Cosignatories, who were not allowed to borrow themselves or cosign another loan so long as they were bound by cosignature to an outstanding loan, could be pursued in the event of default, with fund managers instructed to deduct 2 shillings from the pay of staff members who failed to initiate legal proceedings against delinquent cosignatories to a defaulted loan (Piesse 1841).[6,7] Interest was standardized to 4 pence in the pound per week, or 8% per annum, though additional fees for filing application

[3] Traditional pawnbrokers and Mont-de-Piétés had different lending structures than Loan Funds, and, unlike Loan Funds, required collateral, which meant that potential borrowers had to possess durable assets to pledge.

[4] Assuming an average family size of five, this implies Loan Funds were annually extending loans to roughly 20% of Irish households, though in some counties, the figure was closer to 30–40% (Hollis and Sweetman 1998, 2004).

[5] To put these figures in perspective, *Thom's Statistics of Ireland* for 1853 quotes the following official enumerated values: cattle at £6.50 per head, pigs at £1.25 per head, sheep at £1.10 per head, goats at £0.375 per head, and chickens at £0.025 per head. Market quotes from 1845, however, report £2.25 per head for pigs (£1.00 for a young feeder pig), £0.09 per head for chickens, £9.00 per head for an adult cow, and £1.00 to £2.10 for an adult sheep, depending on gender. Alternatively, seed to sow one acre of oats cost £0.90 (*Thom's* 1850).

[6] There were 12 pence (d.) in a shilling, and 20 shillings (s.) in a pound (£). Legally, Loan Funds enjoyed priority over other creditors (McLaughlin 2009).

[7] Charles A.J. Piesse was a British civil servant at Dublin House and Secretary of the Loan Fund Board of Ireland. His publication, *Sketch of the Loan Fund System in Ireland and Instructions for the Formation of a New Society*, was intended not just as a guide for the establishment of Loan Fund societies, but also to encourage establishment. The publication therefore likely overstates the degree of uniformity and regulatory consistency within the Loan Fund system.

cards and promissory notes, and for screening sureties, could raise effective rates to 9–12%, with penalties for late payments potentially adding a further 1–5% on an annualized basis.[8]

Lending was explicitly intended for low-income, rural borrowers, with small farmers, cottiers, and agricultural laborers comprising the majority of loan recipients. Approximately 20% of borrowers were women. From 1838, funds were overseen by a central board, the Loan Fund Board, that standardized rules and accounting practices though management and operations remained decentralized. The board also issued annual reports, which include illustrative examples of Loan Fund lending. The 1841 report mentions a borrower who "holds a small mountain farm; got a loan, and laid out 4*l*. on flax, which enabled him to set his four girls at work, spinning; with their help, he paid the instalments, and was 4*l*. better at the end; bought a cow for that sum, which is now worth 6*l*.; has at present three cows, and says he is so well off that he may give up borrowing" (*Third Annual Report of the Loan Fund Board* 1841). The same report describes "A.B., formerly a day labourer, and frequently assisted by a kind neighbour in the maintenance of his family, has, by means of the Loan Fund, raised himself to independence, and is now possessed of a cow, a pony, and a good cart, with a small patch of land, which he farms to good purpose."[9]

Funds were operated by paid clerks, and predominantly funded by interest-earning deposits (Hollis and Sweetman 1998).[10] A standard 5% annual

[8] Interest was originally set at 6 pence in the pound, or 12% on an annualized basis, though was lowered to 4 pence in the pound in 1843.

[9] Consider also: "I. K. applies for the sum of £l to buy a pig; he states he has sufficient food for his family, but that the offal of his house is going to loss because he has no pig to consume it; he receives the £1 with which he purchases the pig, that which was heretofore going to loss supports it, the animal increases in value according to the ordinary calculation a shilling a-week.—if this increased value was available every week, then he might pay the instalment, and at the end of twenty weeks he would have paid the money borrowed and have the pig 'to the good;' but as the increased value of the pig is not available every week, he pays one shilling a-week out of his wages, and at the end of twenty weeks he has paid off the loan, and is in possession of a pig worth at least forty shillings" (Piesse 1841).

[10] Some funds also received charitable donations. In the following empirical analysis, however, I do not incorporate gifts directly because they do not appear as a line item in the annual reports of the Loan Fund Board, nor do they appear as residuals in the balance/loss column, which leads me to conclude that they were not a substantial component of revenue. However, gifts are reflected in the average cost of capital (as gifts were interest free, they would have lowered the average cost of capital), which means I do implicitly control for variation in gifts.

rate on deposits (reduced from 6% in 1843)—nearly twice the rate typically offered by conventional joint-stock banks—allowed the Loan Funds to attract considerable depositor interest. The majority of depositors, however, in contrast to borrowers, were large-volume depositors, with a mean pre-famine deposit size of £46. Piesse (1841) notes that most depositors held deposits of £50 or more, an observation confirmed by McLaughlin (2009), who finds that 44% of depositors in 1840 held £50 or more, with a further 20% holding between £10 and £20. Loan Fund debtors and creditors were therefore for the most part drawn from nonoverlapping economic sectors and income strata. Nonetheless, Ó Gráda (1999, 2008) finds that the general equilibrium effects of the famine on the deposit base of Irish financial institutions were substantial, as lower aggregate demand and the need for higher nutritional efficiency wages for farm laborers imposed severe negative income shocks on middle- and upper-income depositors, forcing many to withdraw funds from savings institutions.

1.1.2 The Great Famine and the Irish Loan Funds

While instances of food shortages owing to periodic failure of the potato crop were not unknown in Ireland before 1845, such crises were typically geographically and temporally limited, with the statistical probability of successive failures negligible (Mokyr 1985; Solar 1989; Ó Gráda 1995, 1999).[11] The risk of a one-off disappointing harvest thus did little to halt what Irish economic historian Austin Bourke called "a sinister trend toward monoculture," with the potato accounting for approximately 60% of the Irish food supply, and nearly 40% of Irish depending almost exclusively on the potato by the eve of the Great Famine (Bourke 1993). The proximate cause of the Great Famine, then, was the arrival in Ireland of the oomycete *P. infestans* in autumn 1845. The disease, which rots the tubers of infected potatoes, most likely originated in the central Mexican highlands, traveling to Ireland via West Flanders, where in 1843, the provincial government funded importation of new potato varieties from the Americas. By late summer 1845, the fungus had spread throughout

[11] Solar (1989) finds pre-blight variation in French potato crop yields suggests the probability of a singular major failure was small and that, before the arrival of *P. infestans*, the probability of two or three successive failures was essentially nil.

Flanders and neighboring regions in the Netherlands, northwestern France, lower Rhineland, Channel Islands, and southern England. On 6 September, press reports announced the first observations of potato disease in Ireland (*Dublin Evening Press* 1845).

Affecting only potatoes, the disease was known as "late blight," as the effects typically do not become apparent until relatively late in the growing season.[12] *P. infestans* spores germinate on the leaves of potato plants, spreading to host tubers when temperatures rise above 10°C (50°F) and humidity over 75–80% for two or more days. By the time dark blotches on leaf tips and plant stems reveal the presence of blight, infection is already terminal, and the plant will quickly decay. Entire fields can thus be destroyed in a matter of days.[13] Since the potato was at the time primarily a subsistence crop, rapidly reproducing spores were typically spread by wind rather than by trade, traveling up to 50 miles a week (Koepsell and Pscheidt 1994).[14]

Though the relatively late arrival of blight in Ireland allowed roughly 60–70% of 1845s above-average potato crop to survive, in 1846, after an unusually damp spring and summer, potato crop failure was catastrophic, with an estimated 75% of the island's harvest lost to blight (Ó Gráda 1999). Yields recovered somewhat in 1847, but the devastation of 1846 had left seed potatoes in scarce supply, which resulted in "Black '47" turning out to be the most deadly of the famine years. Moreover, after two years of potato crop failure, many Irish farmers had already been compelled to sell their scant livestock holdings, which meant stocks of pigs and poultry—traditional income buffers against adverse harvest fluctuations—were largely exhausted by 1847.[15]

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[12] Blight can also affect tomatoes, but tomatoes were rarely grown in pre-famine Ireland, and there is no mention in the historical literature of the effect of blight on negligible tomato cultivation in Ireland.

[13] *P. infestans* spores winter on tubers of the previous year's crop that have been left in the ground as seed or in cull piles. Attempts at early harvest of an infected crop are likely to be in vain, as infected tubers will deteriorate quickly in storage (Zwankhuizen, Govers, and Zadoks 1998).

[14] *P. infestans* remains difficult to manage even today. Genetic engineering of resistant varieties, proper field hygiene, and use of fungicides are common tools for preventing or combating blight, but continually evolving resistance remains a challenge (Zwankhuizen, Govers, and Zadoks 1998).

[15] Given that successive crop failures were virtually unheard of before 1845, many farmers expanded potato plantings in 1846, confident of the improbability of back-to-back failure. Livestock were rarely consumed directly, but rather sold as pork, eggs, and butter to national and international markets, with the proceeds used to buy cheaper food substitutes (Ó Gráda 1995, 1999).

While blight would reassert itself in 1848 and with less intensity in 1849 and, in certain regions, in 1850, the winter of 1846–47 marked the worst of the disaster. By 1851, the outbreak had essentially run its course. However, although the blight receded after 1851, it nonetheless remained a persistent threat, with yields exhibiting considerably greater volatility than before 1845. The 1872 and 1877–79 potato crops were particularly hard-hit, with many historians and contemporary observers reckoning the failure of the 1879 harvest comparable to that of 1846 (Davidson 1933; Bourke 1960).[16] Moreover, the persistent presence of blight meant a permanent drop in normal per-acre yields from pre-famine levels (Ó Gráda 1995). Bourke (1993) estimates that save a few notable exceptions, it was not until the mid-twentieth century that annual potato crop yields again attained pre-1845 levels. Before 1845, potato yields per acre averaged 6–7 tons. During the post-famine period from 1856 to 1880, average annual yield was only 3.2 tons per acre. Even after the discovery of copper sulfate as a partially effective antidote in 1882, yields did not fully recover to pre-famine levels; on the eve of the First World War, per-acre yields were still just under 5 tons (Ó Gráda 1995).

Long-run vulnerability to blight was, however, unevenly distributed. While the spread of *P. infestans* spores was indiscriminate, the severity of blight infection was not. *P. infestans* thrives in moist, temperate, and humid conditions, hence why the unusually wet summers of 1846 and 1879 were exceptionally favorable to blight (Bourke 1965b). Consequently, regions whose typical climatic conditions, particularly in late summer, were especially hospitable to blight faced permanently higher probabilities of reduced harvests. Thus, in addition to inflicting a major transitory shock on the Irish agricultural economy, the arrival of blight also constituted a permanent, regionally variated, adverse disturbance both to normal potato yields and to yield volatility.

Given their low-income, agrarian clientele and the high spatial correlation of the environmental shock to agricultural incomes, many Loan Funds struggled during the famine years, ostensibly as repeated crop failures led to higher default rates (Hollis and Sweetman 2004). McLaughlin also notes that though most depositors were not directly affected by the failure of the

[16] The harvests of 1860–2, 1890, 1894, and 1897 were also especially adversely affected by blight.

potato crop, some withdrew their savings out of concern for the solvency of any institution lending to low-income debtors (McLaughlin 2009). Of the 300 funds operating in 1843, only 123 remained by 1852, while the average amount circulated per fund fell from £6197 in 1845 to £2438 in 1847. The following year, 58 funds had to wind up. Nonetheless, many funds remained active throughout the famine years, and many of those that survived eventually recovered and returned to profitability. Even during the worst years of 1846 and 1847, Loan Funds managed to extend 459,360 and 223,465 loans, providing, respectively, £1,712,638 and £834,855 of credit to Ireland's rural poor.[17,18]

It is also important to note that the Loan Funds suffered from several institutional flaws, which may have rendered them more vulnerable to adverse shocks such as the famine. Though the annual reports of the Loan Fund Board indicate that a handful of funds operated jointly with associated Mont-de-Piétés, in general the Loan Fund system was highly decentralized and exhibited considerable heterogeneity in the quality and consistency of management. Therefore, not only were the Loan Funds severely limited in their ability to absorb shocks through asset- and liability-side geographic diversification and private or public insurance, but many funds also suffered from severe corruption and rent-seeking on the part of managers and clerks (Hollis and Sweetman 2001; McLaughlin 2009).[19] McLaughlin (2009) further finds that ministers may have been less effective managers than non-clergy not, as Hollis and Sweetman (2004) surmise, due to a more lenient approach to delinquent borrowers, but rather due to laxer monitoring of their own staff.

[17] In the first two years of the famine, Loan Funds extended an average of 2375 and 3297 loans in baronies with a mean pre-famine population of 30,876. In 1849, Loan Funds still extended an average of 1886 loans per fund. Cumulatively during the famine years, Loan Funds extended one loan for nearly every two men, women, and children of the 1841 population in those baronies, with a mean loan size of £3.56.

[18] Hollis and Sweetman (2004) find that prudential management before the famine was the most important predictor of fund survival; the maintenance of lower leverage ratios before the famine and having non-clergy managers were strongly associated with survival, while population decline and pre-famine measures of wealth and poverty were poor predictors.

[19] Though Besley (1995) observes that higher-tier agency problems remain an issue with more contemporary MFIs as well.

1.2 Data Construction

This study utilizes original data from numerous archival sources. First and foremost, since there was no previous indicator of micro-variation in blight, I construct an index of blight severity at the baronial level using constabulary reports from the Distress Papers of the Parliamentary Relief Commission.[20] The Relief Commission was established by the British government in November 1845, in response to the failure of the potato crop in Ireland, in order to advise the government concerning the extent of potato loss and distress in Ireland, to oversee the storage and distribution of emergency Indian corn and meal, and to administer the activities of local relief committees. In practice, though, the Commission had little real authority beyond coordinating the collection of data. To discharge its duties, the Commission regularly solicited reports from local officials regarding the state of the potato crop, extent of blight infection, and the condition of the local populace. Reports and incoming letters were received from local constables, coast guard officials, lieutenants of counties, resident magistrates, and Poor Law guardians.

To assess the level of local blight severity, I rely on reports received between November 1845 and August 1846, when the Commission was disbanded, with most reports received in July/August 1846. Based on these reports, I designate each barony as low, medium, or high impact, corresponding to moderate, considerable, or severe blight infection. In the case of quantitative reports, I define a low- or moderate-impact barony as a barony with less than one-third of its potato crop infected by blight. Medium- or considerable-impact baronies are baronies with a one-third to two-thirds infection rate, and high- or severe-impact baronies experienced crop infection rates in excess of two-thirds. For baronies with only qualitative reports, I use language such as "very good," "trifling," and "partially infected" to designate low-impact baronies; "considerably infected" or "very much infected" to designate medium-impact baronies; and "generally very bad," "extensively infected," and "very

[20] Previous studies have used estimated excess mortality as a proxy for blight severity, but that method is flawed because mortality is itself an outcome variable.

extensively infected" to designate high-impact baronies.[21] The geographic dispersion of blight severity is illustrated in Fig. 1.1.[22]

Reports issued at the larger administrative unit of Poor Law Union (PLU) I assign to baronies according to the location of the reporting official. In increasing order of size, Irish administrative units proceed from townland to civil parish to barony to PLU to county to province. Several baronies were split or merged after 1851. For those that split, I sum statistics for the successor baronies to preserve continuity. For those that merged, I sum statistics for the predecessor baronies and weight blight index scores by predecessor area. Altogether, I am thus able to assign a blight severity designation to 255 of the 323 baronies in Ireland on the eve of the famine, representing all four Irish provinces, all 32 counties, and 105 of 163 PLUs. The main sample is therefore a panel of these 255 baronies from 1821 to 1891. Since some years and outcome variables lack baronial-level data, I also classify each PLU as suffering low–medium or medium–high blight severity, based on averages of constituent baronial levels, weighted by area.[23] This secondary sample is a panel of 105 PLUs from 1844 to 1891.[24]

Data on lending activity by the Irish Loan Funds is from the annual reports of the Commissioners of the Loan Fund Board of Ireland. Pre-famine baronial valuations are from the 1845 *Appendix to the Minutes of Evidence Taken before Her Majesty's Commissioners of Inquiry into the State of the Law and Practice in Respect to the Occupation of Land*

[21] The majority of reports, like the sample provided in Fig. 1.1, consist of both qualitative and quantitative assessments of blight severity. To ensure equivalent coding of qualitative and quantitative reports, I rely on these mixed reports to link particular vocabulary with corresponding quantitative accounts. For example, "extensively" and "generally" were universally associated with estimated crop infection rates in excess of 75%, whereas "considerably" and "very much" or "quite" were typically associated with infection rates near 50%. Nonetheless, in Table 1.3, I include a categorical variable for whether a report was qualitative, quantitative, or both to test for whether the type of report explains variation in blight index scores. It does not.

[22] Note that many baronies do not appear in the sample. This is because there were no surviving reports in the Relief Commission papers for these baronies. Numerous official Irish records were lost in June 1922, during the Irish Civil War, when the Public Record Office was destroyed by fire.

[23] Because aggregating blight observations at the PLU level leaves no exclusively low or moderately affected observations, I have to reclassify blight severity as a single binary variable.

[24] For baronial-level analysis of average changes in crop acreage, the main panel includes the years 1844 through 1871, and the years 1847 through 1871 for average changes in the value of livestock holdings. For PLU-level analysis of average changes in farm size, the secondary panel includes the years 1845 through 1871.

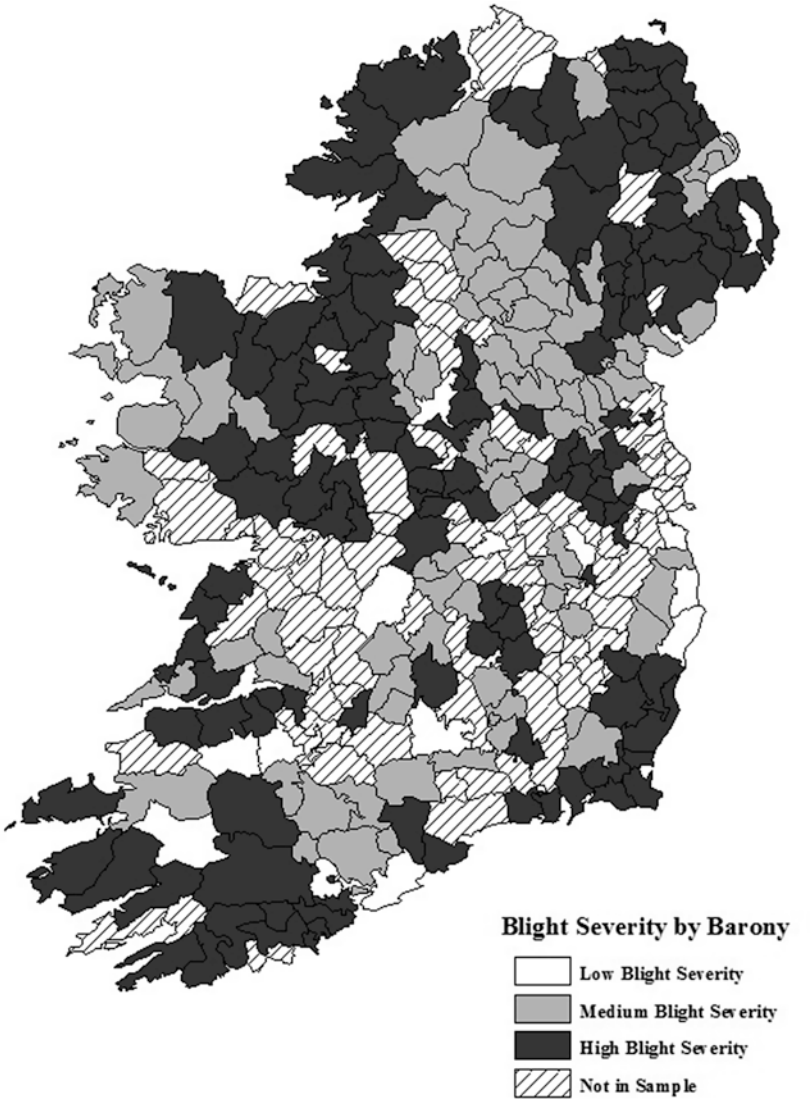

Fig. 1.1 Geographic distribution of blight severity

in Ireland.[25] Unfortunately, data on farm size do not exist at the baronial level before the arrival of blight in 1845. However, the *Appendix to the Minutes of Evidence* lists the number of landholders in each PLU by holding size.[26] An additional constraint is that, for landholdings of 5–50 acres, while the returns listed in the *Minutes of Evidence* divide at 5, 10, and 20 acres, returns from the agricultural surveys of 1848–50 divide at 15 and over 30 acres, and returns after 1850 divide at 15, 30, and 50 acres. It is therefore only possible to consistently analyze changes in the share of total farmholdings under 1 acre and between 1 and 5 acres. Livestock prices are compiled from Alexander Thom's *Statistics of Ireland*, from *Thom's Irish Almanac and Official Directory*, an annual almanac of Irish statistics. All other baronial- and PLU-level data were assembled using the decennial *Census of Ireland* (1821–1891), *Returns of Agricultural Produce in Ireland* (1847–1856), and *Agricultural Statistics of Ireland* (1857–1871).[27] Summary statistics are reported in Table 1.1. Summary statistics for balance sheet metrics and failure rates for all in-sample funds are reported in Table 1.2.

It is important to note that by the time the blight had run its course in 1851, virtually no part of Ireland had been completely spared, and even baronies designated as low impact experienced significant blight infection. Furthermore, my index of blight severity solely measures blight severity in 1845 and 1846 in observed baronies. Baronies designated as low impact may subsequently have become severely impacted as blight spread throughout the island. However, as noted above, *P. infestans* thrives in moist, temperate, and humid conditions, hence why the unusually wet summer of 1846 was exceptionally favorable to blight (Bourke 1965b). Consequently, regions whose typical climatic conditions, particularly in late summer, were especially hospitable to blight faced permanently higher probabilities of severe outbreaks. Thus, insofar as variation in

[25] The *Minutes of Evidence* were the official report of the Devon Commission appointed by the government of Sir Robert Peel to research landholding in Ireland. The commission was headed by William Courtney, the 10th Earl of Devon.

[26] *Minutes of Evidence* were submitted to the British House of Lords on 5 May 1845, before the arrival of blight.

[27] All three surveys were commissioned by Parliament and have been digitized by Clarkson et al. for the *Database of Irish Historical Statistics*. For full documentation, see Clarkson et al. (1997).

Table 1.1 Summary statistics

	Population	Potato crop share	Under 5-acre share (PLU)	Buffer livestock		Grazing livestock	
				0–15 acres	*>15 acres*	*0–15 acres*	*>15 acres*
1841	26,909.660						
1845		0.440	0.330				
1846							
1847				727.550	2185.678	15,606.22	49,651.47
1848			0.198	780.743	2219.319	13,110.88	52,738.54
1849			0.194	997.426	2797.225	12,339.35	54,363.86
1850				1063.767	3254.304	11,802.56	57,885.48
1851	21,337.17						
1852		0.215	0.195	1237.571	3662.393	11,272.91	63,434.40
1856		0.303	0.199	1058.333	3375.460	13,208.68	76,398.99
1861	18,908.54	0.285	0.207	1328.680	3897.315	12,463.25	73,829.36
1871	17,002.16	0.243	0.211	1978.716	5594.507	13,857.34	85,961.13
1881	15,930.56						
1891	14,092.43						

Notes: Each column reports average levels for the sample in the indicated years. Potato crop share is the fraction of total tillage acreage under potato crop, and under 5-acre share is the fraction of all farms under 5 acres. Livestock holdings are reported in aggregate pounds sterling value terms.

blight severity in 1845–46 reflected variation in climatic hospitability to blight, observations of blight severity in 1845–46 will reflect both short-run and subsequent long-run variations in exposure to blight.[28]

To confirm this correspondence between micro-variation in blight severity in 1845 and 1846 and long-run susceptibility to blight, in Fig. 1.2, I plot per-acre potato yield data at the Poor Law Union level from a preliminary parliamentary report of the 1879 *Returns of Agricultural Produce in Ireland* survey against blight severity in 1845–46. The failure of the 1879 harvest is generally reckoned to have been comparable to that of 1846 owing to particularly bad outbreaks of *P. infestans* (Davidson 1933; Bourke 1960). The graph reveals a strong negative correlation between blight severity in 1845–46 and 1879 per-acre potato yields—higher

[28] Consistent with this, Cousens (1960b, 1962, 1964) finds that after the near-universal distress of 1847, pre-famine poverty conditions exerted negligible influence on excess mortality, emigration, and conjugal statistics, as distress was determined more by local conditions of the potato harvest.

Table 1.2 Summary fund statistics

	Mean (1)	Std. dev. (2)	Min (3)	Max (4)
Panel A: 1841–1844				
Number of loans	1754.246	1752.177	89.000	17,211.000
Total lending volume	6076.330	6736.067	141.500	59,407.000
Leverage ratio	4.044	1.073	0.776	12.889
Average interest rate	0.115	0.063	0.037	0.601
Fines ratio	0.032	0.031	0.000	0.344
Loan size	3.247	1.052	1.000	6.927
Bad debts	6.234	18.394	−25.000	154.250
Average salary	17.135	12.031	0.000	70.875
Expense ratio	0.002	0.002	−0.001	0.020
Cost of capital	0.041	0.016	0.000	0.090
No. of depositors	23.715	26.189	0.000	175.400
Profit margin per loan	0.060	0.051	−0.194	0.247
Manager a minister	0.406	0.492	0.000	1.000
Panel B: 1846–1852				
Severe blight	0.518	0.501	0.000	1.000
Fund survive 1852	0.515	0.501	0.000	1.000
Number of loans	1454.968	1472.827	54.000	15,466.000
Total lending volume	5393.321	5589.421	141.500	50,334.670
Leverage ratio	2.179	6.164	0.428	80.607
Average interest rate	0.098	0.089	0.021	1.148
Fines ratio	0.030	0.038	0.001	0.444
Loan size	2.631	1.812	0.000	6.547
Bad debts	3.319	21.178	−26.667	263.000
Average salary	8.325	5.163	0.733	28.500
Expense ratio	0.002	0.004	−0.002	0.050
Cost of capital	0.026	0.085	0.000	1.107
No. of depositors	20.134	21.335	0.000	185.000
Profit margin per loan	−0.017	0.128	−0.882	0.179
N			239	

Notes: Each row reports the mean, standard deviation, minimum, and maximum values for the indicated variable for all in-sample funds. Loan Fund financial metrics are annual averages for the 1841–44 (pre-blight) and 1846–1852 (famine) periods. Average leverage ratio is total lending divided by capital. Average salary is the total wage bill divided by the number of employees. Gross profit margin per loan is gross revenue minus total expenses, divided by the number of loans. Expense ratio is total expenses, less wages and capital costs, divided by total lending. Cost of capital is interest payments divided by capital. Fines ratio is total fines collected divided by total lending. Interest rates are calculated by dividing total interest income (including application and surety screening fees) by total lending.

blight severity in 1845–46 was associated with a 238.459-pound lower per-acre yield in 1879—consistent with long-run vulnerability to blight varying by location.

Though there is no historical evidence that either the incidence of blight severity, reporting to the Relief Commission, or location of Loan Funds was correlated with non-fixed baronial characteristics that were also correlated with post-famine outcomes, to test these identifying assumptions, I regress blight severity, non-reportage to the Relief Commission, Loan Fund presence, and average annual Loan Fund lending during the first five years of the famine (1845–50) on pre-famine baronial characteristics, with results presented in Table 1.3. To further test whether my blight severity index maps onto late-summer climatic conditions hospitable to blight, as strongly suggested by Fig. 1.2, I also regress blight severity on local average July air and soil temperature and humidity.[29] Finally, to test for coding consistency, I include a categorical variable for whether the blight report was qualitative, quantitative, or both.

OLS-estimated coefficients presented in column 1 of Table 1.3 indicate that pre-famine baronial characteristics are poor predictors of blight severity. None of the estimated coefficients for baronial literacy, population density, potato crop share, fourth-class housing, or religious diversity are statistically significant, and the fit is poor.[30] Estimated coefficients on the potato crop share of total crop acreage and fourth-class housing indicate that officials were no more likely to report severe blight infection where potato dependence was higher and poverty greater. The estimated coefficient on baronial valuation is statistically significant, though it is small in size and significant only at the 10% level. While mean July soil temperature is not a statistically significant predictor of blight severity, the estimated coefficients for mean air temperature and humidity are positive and statistically significant, which is consistent with slightly warmer, more humid late-summer atmospheric conditions being more hospitable to spore germination. Whether a report was qualitative, quantitative, or both

[29] In the absence of pre-famine climate data, I use contemporary averages from Met Éireann, the Irish National Meteorological Service.

[30] In the *Census of Ireland*, fourth-class houses are defined as "all mud cabins having only one room."

Table 1.3 Estimated blight severity, Loan Fund presence, Loan Fund lending, and musical society presence by pre-famine characteristics

	Blight severity (1)	Non-reporting (2)	Loan Fund (3)	Lending (4)	AIMS (5)
Valuation	0.000*	–0.000	0.000	–0.005	0.000
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Literacy rate	0.205	0.077	–0.384	4310.535	0.189
	(0.40)	(0.45)	(0.45)	(3052.03)	(0.43)
Religious diversity	–0.336	–0.033	–0.954	–2517.238	–0.258
	(0.73)	(0.56)	(0.64)	(4329.04)	(0.61)
Population	0.006	0.009	0.005	454.565***	0.024
density	(0.02)	(0.03)	(0.02)	(139.81)	(0.02)
Fourth-class	–0.046	0.116	–0.423	–1301.827	–0.122
housing	(0.41)	(0.42)	(0.35)	(2379.84)	(0.34)
Potato crop share	15.689	36.031	0.647	6188.983	0.33
	(46.73)	(49.78)	(0.90)	(6149.65)	(0.87)
Mean July air	0.311*				
temp (C°)	(0.16)				
Mean July soil	0.149				
temp (C°)	(0.16)				
Mean July	0.028*				
humidity (%)	(0.02)				
Relief Commission Report					
Qualitative v.	0.049				
Quantitative	(0.10)				
Both	–0.133				
v. Quantitative	(0.10)				
N	206	242	206	206	206
R2	0.142	0.033	0.138	0.331	0.119

Notes: Each column reports OLS-estimated coefficients for differences in blight severity, population decline, Loan Fund presence, average annual Loan Fund lending from 1845 to 1850, and AIMS Musical Society presence by pre-famine baronial characteristics. Standard errors are reported in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

does not appear to have had an effect on assessed blight severity. Similarly, OLS-estimated coefficients reported in column 2 of Table 1.2 indicate that pre-famine characteristics are poor predictors of whether a report exists in the Relief Commission papers for a given barony; none of the estimated coefficients in column 2 are statistically significant, and the fit is poor.[31]

[31] The dependent variable is a binary variable equal to 1 if a report for barony *i* exists in the Relief Commission papers, and a 0 otherwise.

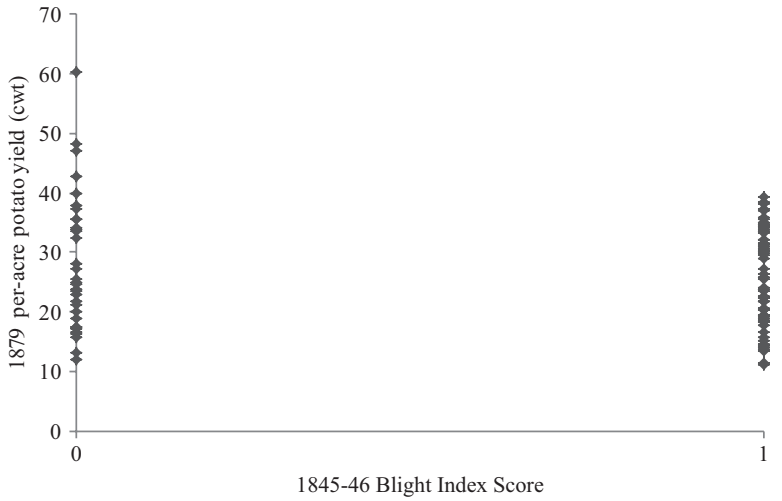

Fig. 1.2 1845–46 Blight severity vs. 1879 potato yields (Notes: Figure 2 plots per-acre potato yields (in hundredweights) in 1879 by blight severity in 1845 and 1846 at the PLU level. *Source*: *Returns of Agricultural Produce in Ireland* (1879))

Estimated coefficients presented in columns 2 and 3 of Table 1.3 indicate that pre-famine characteristics are also poor predictors of the presence of at least one active Loan Fund and average annual Loan Fund lending during the famine years. None of the estimated coefficients in column 2 are statistically significant, and the fit is poor. In column 3, higher pre-famine population density, which Mokyr (1985) and Ó Gráda (1999) use as a proxy for poverty, is positively associated with the volume of Loan Fund lending, though the remaining variables are not correlated with differential microcredit supply during the famine. Notably, social capital, as proxied by a Herfindahl index of religious diversity, appears to have had no statistically significant effect either on Loan Fund presence or the scale of Loan Fund lending during the famine.[32]

The organization of the remainder of this book is as follows. In Chap. 2, "Mapping the Famine," I analyze local differences in adapta-

[32] For Loan Fund regressions, I include a Herfindahl index of religious diversity in 1861, the first year for which data on religious affiliation is available, as a proxy for social capital. The variable is thus $R = \sum_{i=1}^{N} p_i^2$ where p_i is the proportion of all religious affiliates belonging to denomination i and N is the number of religious denominations.

tion to potato blight, exploiting micro-variation in blight severity to examine how Irish farmers adjusted to the major environmental shock in the short, medium, and long runs. I also construct a theoretical model in which a representative farmer must determine the optimal fraction of fixed acreage to allocate to different crops, and the optimal number of buffer livestock to invest in, so as to maximize his net expected return while minimizing total portfolio volatility, subject to uncertainty. In Chap. 3, "Credit and Adaptation," I shift focus to the role of credit institutions and adjustment to the shock of potato blight. I also extend the theoretical model constructed in Chap. 2 in order to incorporate the possibility of the farmer operating under conditions of constrained credit. Chapter 4, "Surviving the Famine," examines the effects of the Great Famine on the Irish Loan Funds themselves and explores the management and lending practices that allowed some Loan Funds to survive a major covariate shock while others failed. In Chap. 5, "Was Malthus Right?," I revisit a central question in the economic literature on the Great Famine, namely, whether variation in pre-famine "Malthusian" variables can explain subsequent variation in famine outcomes. I find that results are generally inconsistent with a predominantly Malthusian account of the disaster. Finally, in Chap. 6, "The Great Famine in the Short and Long Run," I summarize the results of the preceding four chapters and situate them within the larger literature on the Great Famine of Ireland. I argue that while these results do not challenge more traditional explanations of the Great Famine, they do demonstrate, first, how marginal adjustments differed where the environmental shock was marginally more severe; and, second, how relative marginal adjustments differed where, controlling for the severity of the environmental shock, one binding constraint was partially relaxed. I furthermore discuss the implications of my findings for contemporary issues in development economics.

2

Mapping the Famine

> With autumn the real famine began. Though the potato failure had probably not exceeded that of the previous year, there were now no other resources on which to draw. A few pigs had survived the slaughter of 1845–1846, but the blighted fields foretold their doom. The swine were driven half-fed to market—a pathetic reminder of the six or seven hundred thousand which were usually sent across the Irish Channel to England. – Marcus Lee Hansen, *The Atlantic Migration* (1940)

An important feature of agricultural economies with incomplete markets is that short-run adjustments to adverse production shocks are often impeded by binding constraints that may be relaxed only over the long run (Swinton 1988; de Janvry et al. 1991; Besley and Case 1993; Foster and Rosenzweig 1995; Conley and Udry 2010). In particular, uncertainty, as well as capital and land constraints, can result in demographic change constituting the primary short-run margin of adjustment (Rosenzweig and Stark 1989; Townsend 1994; Udry 1994; Dercon 1996; Fafchamps et al. 1998; Munshi 2004). Research has also demonstrated that production shocks in the form of adverse environmental change are especially harmful

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to developing economies and their poorest populations, with the threat likely to intensify (Jayachandran 2006; World Bank 2009; Dell et al. 2012). Thus, while recent studies have analyzed economic adaptation to environmental change in more developed settings, it is increasingly important to understand such adjustment in developing contexts (Deschenes and Greenstone 2007; Hornbeck 2012). Historical episodes provide a unique opportunity to analyze both short- and (very) long-run adaptation to environmental shocks than is possible in more contemporary studies (Reardon et al. 1992; Gine and Klonner 2005; Kazianga and Udry 2006; Duflo et al. 2008). Moreover, as the incidence of adjustment to a large shock along different economic margins may vary considerably depending on the relevant time horizon, it is critical to examine such responses with a long historical perspective (Lange et al. 2009).

In this chapter, I therefore provide a preliminary analysis of the margins of adjustment to the arrival of blight in Ireland excluding the potential role of credit institutions. The empirical approach is based on estimating average changes for baronies more severely infected by blight relative to less severely infected baronies. I find that regions suffering more heavily from *P. infestans* experienced greater short-run accumulations of buffer livestock by small- and medium-sized farms and short- to medium-run population declines, while over the medium and long runs, adaptation occurred through substantial and permanent substitutions away from potato cultivation toward other tillage crops and, for medium-sized farms, grazing livestock. Specifically, baronies that were severely or considerably infected by blight in 1845 and 1846 experienced population declines that were 17.3% and 13.0% greater by 1851 than moderately infected baronies, with the gap persisting through the end of the century.

In the short run, small- and medium-sized farms in baronies severely or considerably affected by blight increased stocks of poultry and pigs—traditional buffers against crop failure—relative to analogous-sized farms in moderately affected baronies, while in the long run, more severe blight infection was associated with greater increases in holdings of grazing stock by medium-sized farms, particularly cattle and sheep. Micro-variation in blight severity appears to have had no differential

impact on changes in livestock holdings by the largest farms. Further, only after two successive harvest failures did more adversely impacted baronies begin to substantially reduce acreage under potato crop, with the potato's share of total tillage acreage in the long run declining by 15.7 and 12.3 percentage points more in severely and considerably versus moderately impacted baronies.

2.1 Theoretical Framework

The arrival of blight in Ireland was a major shock that permanently affected potato yields. Not only were per-acre potato yields permanently lower after 1845, they were also subject to much higher volatility. To motivate the empirical analysis, I therefore construct a model in which a representative farmer must determine his optimal allocation of land between alternative agricultural uses so as to maximize his net return per acre while minimizing risk, subject to constrained credit and uncertainty over whether yield shocks are permanent or transitory.[1]

For analytical purposes, I initially suppose the farmer's choice to be between two crops, *i* and *j*. While previous studies have assumed the crop acreage decision to consist of a choice between a "traditional" crop with a certain yield and a risky "modern" crop of uncertain yield, I instead develop a more general case in which the farmer faces a choice between two crops, both of uncertain yield but with unequal variances (Feder 1980; Foster and Rosenzweig 1995; Munshi 2004; Duflo et al. 2008). The extension of uncertainty to both crops is intended to capture the historical reality that there was no clear "risk-free" crop available to Irish farmers. Though the potato may have been the "traditional" crop, its yield, particularly after 1845, was subject to considerable volatility, the change in which had to be learned by observation and determined to be a transitory or permanent shock. At the same time, not only were yields of alternative crops also subject to uncertainty, they too had to

[1] The model could easily, however, refer to any alternative land uses, for instance, the choice between crop tillage and pasture for livestock grazing.

be learned by observation, especially as they were less familiar to Irish farmers than the potato.

Assuming constant returns to scale for both crops, the yield for crop i, j in year t is specified as $Y_{i,jt} = y_{i,j}(Z) + \eta_{i,jt}$, where $y_{i,j}(Z)$ is the expected yield and Z a vector of soil and other plot characteristics. For simplicity, I assume that Z is time-invariant. $\eta_{i,jt}$ is a mean-zero serially independent disturbance term, with variance $\lambda_{i,j}^2$, that captures deviation from the true yield, $y_{i,j}(Z)$, obtaining under normal growing conditions: $E_{i,j}(\eta_{i,jt} | y_{i,j}(Z)) = 0$.[2]

2.1.1 Acreage Allocation with Perfect Information

I consider first the farmer's optimization problem assuming perfect information about true yield. In this case, $y_{i,j}(Z)$ is known with certainty. Given output prices, p_{it} and p_{jt}, and variable input costs, c_{it} and c_{jt}, the farmer chooses optimal acreage, A_{it}^*, to allocate to crop i so as to maximize the utility of expected profit, π_t, in each period, where $\pi_t = \left(p_{it} y_i - c_{it}\right) A_{it} + \left(p_{jt} y_j - c_{jt}\right)\left(\bar{A} - A_{it}\right)$ and $\bar{A}$ is the total farm area available for cultivation.[3] The outcome, π_t, is thus a linear function of $y_{i,j}$. Assuming outcomes are normally distributed, meaning $\eta_{i,jt} \sim N(0, \lambda_{i,j}^2)$, we can adopt the portfolio mean–standard deviation approach, such that the farmer chooses A_{it} so as to maximize $\pi(\psi, \Sigma)$, where $\psi \equiv \left(p_{it} y_i - c_{it}\right) A_{it} + \left(p_{jt} y_j - c_{jt}\right)\left(\bar{A} - A_{it}\right)$ and $\Sigma \equiv \lambda_i^2 A_{it}^2 + \lambda_j^2 \left(\bar{A} - A_{it}\right)^2 + 2A_{it}\left(\bar{A} - A_{it}\right)\lambda_i \lambda_j \rho_{ij}$, and ρ_{ij} is the correlation coefficient.[4] Assuming the farmer is risk averse, $\pi(\psi, \Sigma)$ is increasing in ψ and decreasing in Σ; optimal acreage allocated to crop i is therefore

[2] These assumptions imply that a permanent adverse yield shock, like blight, will both lower $y_{i,j}$ and increase the variance $\lambda_{i,j}^2$ of the disturbance term, as normal yield fluctuations will be amplified by the severity of blight in year t.

[3] For convenience of expression, I denote $y_{i,j}(Z)$ simply by subscript, given that Z is time-invariant.

[4] Bourke (1993) finds a negative correlation between potato and grain yields before 1845, suggesting that either crop offered some hedging value against failure of the other in any given year.

an increasing function of the profit differential between crops *i* and *j*, and, for $\lambda_i^2\lambda_j^2 > \lambda_i\lambda_j\rho_{ij}$, a decreasing function of total portfolio variance.[5,6,7]

2.1.2 Acreage Allocation with Imperfect Information

If we instead suppose that the farmer has imperfect knowledge of true yield obtained under normal growing conditions, expected yield, $y_{i,j}$, is uncertain. If $\sigma_{i,jt}^2$ is the variance of the farmer's estimates of the expected yields for crops *i*, *j*, then total crop portfolio variance is

$$\Sigma \equiv \left(\lambda_i^2 + \sigma_{it}^2\right)A_{it}^{\ 2} + \left(\lambda_j^2 - \sigma_{jt}^2\right)\left(\bar{A} - A_{it}\right)^2 + 2A_{it}\left(\bar{A} - A_{it}\right) \times \left(\lambda_i + \sigma_{it}\right)\left(\lambda_j + \sigma_{jt}\right)\rho_{ij}$$

Denoting estimated expected yield as $\hat{y}_{i,jt}$, optimal acreage allocation to crop *i* is

$$\hat{A}_{it}^{*} = A\left(\left(p_{it}\hat{y}_{it} - c_{it}\right) - \left(p_{jt}\hat{y}_{jt} - c_{jt}\right), \lambda_i, \lambda_j, \sigma_{it}, \sigma_{jt}, \rho_{ij}\right)$$

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[5] The first-order condition is

$$\partial\pi / \partial A_{it} = \pi_{\psi}\left(p_{it}y_i - c_{it}\right) - \left(p_{jt}y_j - c_{jt}\right) + 2\pi\left(\lambda_i^2 A_{it} - \lambda_j^2\left(\bar{A} - A_{it}\right) + \left(\bar{A} - A_{it}\right)\lambda_i\lambda_j\rho_{ij}\right) = 0$$

The second-order condition is $\partial 2\pi/\partial 2A_{it} < 0$, or $\lambda_j^2 + \lambda_j^2 > 2\lambda_i\lambda_j\rho_{ij}$. We are ignoring second-order effects of $(p_{it}y_i - c_{it}) - (p_{jt}y_j - c_{jt})$ on $\pi\psi$ and $\pi\Sigma$.

[6] Note that the model is sufficiently flexible to allow for a nonmarket, pure subsistence farm. In the case of pure subsistence, we can consider yields ($y_{i,j}$) and variable costs ($c_{i,jt}$) in caloric terms, with $p_{i,jt} \equiv 1$. Adding a subsistence constraint, $y_i A_{it} + y_j\left(\bar{A} - A_{it}\right) \geq y_{\min}\bar{A}$, where $y_{\min}$ represents the minimum per-acre yield for a farm of size $\bar{A}$ to allow for bare subsistence, we see that we must also evaluate potential corner solutions at $A_{it} = 0$, which will occur if $(y_{\min} - y_j)/(y_i - y_j) < 0$, and at $A_{it} = \bar{A}$, which will occur if $y_{it} = y_{\min}$. In the event of a corner solution, the implication is that, assuming $y_{i,j}$ is fixed, adjustment will ultimately require a relaxation of the subsistence constraint, meaning either plot consolidation (an increase in $\bar{A}$) or a decline in the number of inhabitants per acre (a fall in $y_{\min}$) through out-migration or mortality.

[7] Potato yields were generally quite high, especially in caloric and nutritional terms, in pre-famine Ireland, and, with the exception of the occasional one-off failure, reliable (Mokyr 1985; Ó Gráda 1999). In the context of the model, a relatively high yield with low volatility would thus generate the monoculture characterizing much of pre-famine Irish agriculture, especially in the presence of a subsistence constraint (see note 6, above).

Acreage allocated to crop i is increasing in the profit differential between crops i and j and, for $\left(\lambda_i^2+\sigma_{it}^2\right)+\left(\lambda_j^2+\sigma_{jt}^2\right)>2\left(\lambda_i+\sigma_{it}\right)\left(\lambda_j+\sigma_{jt}\right)\rho_{ij}$, decreasing in portfolio variance, $\sum$. I assume the farmer bases his estimates on all information pertaining to expected yields received up to the start of year $t-1, \hat{y}_{i,jt-1}$, realized yield at the end of year $t-1, \overline{y}_{i,jt-1}$, and any additional information received during $t-1, \mu_{i,jt-1}$.[8] Applying Bayes' rule, the expression describing the determination of $\hat{y}_{i,jt}$ is $\hat{y}_{i,jt}=\left(1-\beta-\gamma\right)\hat{y}_{i,jt-1}+\beta\,\overline{y}_{i,jt-1}+\gamma\mu_{i,jt-1}$, where β and γ are the weights attached to $\overline{y}_{i,jt-1}$ and $\mu_{i,jt-1}$, respectively.[9]

Intuitively, the velocity with which $\hat{y}_{i,jt}$ converges to $y_{i,jt}$ will depend upon the relative weights the farmer attaches to information conveyed by realized yield at the end of period $t-1$, additional information received during $t-1$, and all information pertaining to expected yields received up to the start of year $t-1$.[10] This framework allows for the farmer's short-run response to increased yield volatility and uncertainty to differ from more permanent long-run adaptation. In other words, the velocity with which his estimated optimal acreage allocation will converge to its true optimum will depend on the velocity with which his yield estimates converge to true expected yields, which will in turn depend on the relative weights he assigns to information received in prior periods. This is important because it allows for his short-run response to differ from his long-run response. In the short run, he is attempting to figure out the nature of the shock to true yield and variance, such that his own estimates will have a higher variance. Only with subsequent observations will the variance of his estimates decline, and his estimated yields converge to true yield.

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[8] Note that $\hat{A}_{it}^{*}$ only converges to A_{it}^{*} as $\hat{y}_{i,jt}$ converges to $y_{i,j}$.

[9] Because the disturbance term $\eta_{i,jt}$ has a mean of zero, a permanent adverse yield shock that increases $\lambda_{i,j}^2$ also implies a lower $y_{i,j}$, the yield obtaining under typical growing conditions. In the short run, this means a larger $\sigma_{i,jt}^2$, as the farmer's yield estimates only converge to $y_{i,j}$ over time. Alternatively, rather than assuming $\eta_{i,jt}\sim N(0,\lambda_{ij}^2)$, we could adopt a mean–variance–skewness or mean–variance–skewness–kurtosis approach to account for the fact that a permanent adverse shock may involve a leftward skewing or increased tailedness of the variance of the disturbance term. The assumption of non-normality, however, introduces needless complexity and does not fundamentally affect the conclusions of the model.

[10] Presumably, the farmer will place more weight on $\hat{y}_{i,jt-1}$ as the number of observed time periods increases, such that we would expect β and γ to be decreasing over time. I omit time subscripts here, however, to simplify exposition.

2.1.3 Allocation with Livestock as a Buffer Stock

Rosenzweig and Wolpin (1993), Dercon (1996), Fafchamps et al. (1998), and Kazianga and Udry (2006) have demonstrated that agricultural households often keep livestock as buffer assets to smooth consumption when income is stochastically variable and capital markets are incomplete. Bourke (1993) and Rosen (1999) demonstrate that this was also true of nineteenth-century Irish agriculture, with pigs and poultry constituting the most common buffer assets. Thus, I suppose that in addition to the choice between allocating acreage between two alternative agricultural uses, the farmer can also choose to invest in L_t heads of non-grazing (and therefore non-acreage consuming) livestock, at a unit price of c_{Lt}, that he can sell during period t for a guaranteed unit price of $p_{Lt} > c_{Lt}$.[11] Again, the farmer maximizes $\pi(\psi, \Sigma)$, where now

$$\psi \equiv \psi_{it} A_{it} + \psi_{jt} \left(\bar{A} - A_{it} \right) + \left(p_{Lt} - c_{Lt} \right) L_t$$

Optimizing A_{it} and L_t, we can then evaluate how the farmer's optimal allocation to livestock changes as the various parameters of the model vary.[12] Essentially, as the parameters of the model are varied, the farmer's challenge is to determine the optimal acreage to allocate to crop i, and the optimal number of buffer livestock to invest in, so as to maximize his net

[11] This is an admittedly unrealistic assumption, as non-grazing livestock, while they required only a negligible acreage allocation—just 150 square feet in the case of a pig—did consume some portion of tillage output as fodder. Bourke (1993) estimates that as much as one third of pre-famine potato output was used as animal fodder. "Fattening" non-grazing livestock for future sale—either directly as pork or indirectly as eggs—was thus in part a function of crop yield. Nonetheless, I assume a fixed return to buffer livestock in order to keep the analysis simple and to reflect the fact that livestock diets, specifically in the case of pigs and chickens, could be supplemented by foraging. In the wild, pigs will eat leaves, grasses, roots, fruits, and flowers, while chickens often scratch the soil for wild seeds, insects, and occasionally even mice. Thom's farmer's almanac reports that pigs "will thrive on the refuse garbage of the farm, such as mangel, and Swedish turnip tops, and such portions of the roots as the cattle do not consume" (Thom's 1850). Pork, poultry, and eggs thus continued to be exported during the famine years as Irish farmers often opted to convert their livestock into cash in order to purchase cheaper food substitutes, such as imported Indian corn (Rosen 1999). Non-grazing stocks thereby effectively served as highly liquid buffer assets in the event of crop failure; for a certain maintenance cost, farmers could ensure that when food or income was scarce, their livestock holdings could be easily liquidated via market sale of their produce or of the stocks themselves.

[12] For derivation, see Appendix 2.1.

expected return while minimizing total portfolio volatility (formally, his expected utility function is increasing in net expected return and decreasing in total portfolio volatility). In particular, we are interested in how optimal investment in livestock varies with estimated yield and yield volatility. We find that, assuming risk aversion, $\partial L_t^*/\partial \sigma_{jt}$, $\partial L_t^*/\partial \lambda_j > 0$.[13] That is, optimal investment in livestock is increasing in the standard deviation of the farmer's estimated yield of crop j and in the standard deviation of the disturbance term of crop j, so any increase in the volatility of crop j's yield will raise optimal buffer livestock holdings.

Taken together, the theoretical model outlined here presents several key predictions. First, the model predicts that a relative decline in the expected yield of a particular crop will result in substitutions toward alternative forms of land use, whether other crops or grazing livestock (pasture). Second, the model similarly predicts that a relative increase in the expected yield volatility of a particular crop will likewise induce substitutions toward other crops or grazing livestock. Third, the model predicts that in the face of a binding land constraint, long-run adjustment to a relative decline in the expected yield of a given crop and/or a relative increase in the expected yield volatility of that crop will induce an increase in farm size and/or decline in farm population, either through out-migration or through mortality. Fourth, the model predicts that a relative decline in the expected yield of a given crop and/or relative increase in the expected yield volatility of that crop will induce larger holdings of "buffer" livestock. However, fifth, the model also predicts that this substitution effect toward buffer livestock will be particularly pronounced in the short run, since in the long run, through repeated observation, the variance of the farmer's estimates of expected crop yields will fall.

[13] $\partial L_t^*/\partial \sigma_{jt}$, $\partial L_t^*/\partial \lambda_j > 0$ if

$$\pi_\Sigma < \frac{\pi_\psi\left(\left(\psi_{it}-\psi_{jt}\right)-\left(p_{Lt}-c_{Lt}\right)\right)}{2\sigma_{it}\bar{A}\left(\mathrm{cov}\left(\eta_{it},\eta_{jt}\right)-\left(\lambda_i^2+\sigma_{it}^2\right)\right)}$$

So long as $\sigma_{it}^2 > 0$, the denominator in this expression is always negative, while the numerator, which represents the difference in marginal net return between crop i and livestock holding, we can assume, is always positive, as otherwise the farmer should have no incentive to cultivate a risky crop i versus investing in a zero-risk livestock asset.

2.2 Empirical Approach

Following Hornbeck (2012), the empirical analysis is based, first, on estimating average changes in baronies more severely infected by blight relative to less severely infected baronies, and, second, estimating average relative changes in more severely infected baronies with a Loan Fund relative to those without, in the same county and Poor Law Union (PLU) and with similar pre-famine characteristics.

To estimate average changes by blight severity, each outcome Y_{bt} in barony b and year t is differenced from its pre-famine value Y_{bpre} in order to construct a panel at the baronial level spanning, depending on data availability for the relevant outcome variable, the years 1841 through 1891. Each difference is regressed on binary variables for medium and high blight severity (B_b^{med} and B_b^{high}), pre-famine baronial characteristics ($\boldsymbol{X}_b$), categorical variables for county (C_t) and PLU (PLU_t), and an error term (ε_{bt}):

$$Y_{bt} - Y_{bpre} = \beta_{1t} B_b^{med} + \beta_{2t} B_b^{high} \boldsymbol{X}_b' \delta + \boldsymbol{C}_t + PLU_t + \varepsilon_{bt} \qquad (2.1)$$

Since farm size data before 1845 and crop data from 1847–51 and after 1871 are not available at the baronial level, I also estimate a modified Eq. (2.1) at the higher observational level of PLU. Because aggregating blight observations at the PLU level leaves no exclusively moderately affected observations, I reclassify blight severity as a single binary variable, with PLUs experiencing either medium–high (considerable to severe) or low–medium (moderate to considerable) blight infection in 1845 and 1846.[14] Each outcome, Y_{ut}, in PLU u and year t is then differenced from its pre-famine value, Y_{upre}, in order to construct a panel at the PLU level spanning the years 1844 through 1891, and the difference is regressed on blight severity $\left(B_u^{med-high}\right)$, pre-famine PLU characteristics ($\boldsymbol{X}_u$), a categorical variable for county (C_t), and an error term (ε_{ut}):

[14]To reclassify blight severity at the PLU level, I average constituent baronial-level blight observations coded 0, 1, or 2 for low, medium, or high blight severity, weighted by baronial area. PLUs with an average >1.5 are classified as medium- to high-impact PLUs (very considerably to severely impacted), while PLUs with an average of <1.5 are classified as low–medium impact (moderate to considerable infection).

$$Y_{ut} - Y_{upre} = \beta_t B_u^{med-high} + \boldsymbol{X}_u'\delta + C_t + \varepsilon_{ut} \tag{2.2}$$

First differencing allows us to control for unobservable baronial characteristics that vary across baronies but are fixed over time, while county and PLU dummies allow us to control for unobservable variables that vary over time but are constant across administrative units. For instance, higher-order district-by-year fixed effects allow us to control for year-specific shocks, such as the Bank Charter Act of 1844, the repeal of the Corn Laws, and the Panic of 1847, which may have differentially affected different regions of Ireland. For non-fixed but observable baronial characteristics, the included controls in Eqs. (2.1) and (2.2) are baronial valuations completed by 1845, area in 1841, adult literacy rate (reading, writing, or both) in 1841, the potato crop share of total tillage acreage in 1844, and the fraction of housing rated fourth class in the 1841 census. In the absence of income or wealth statistics, these variables are included as proxies for development and poverty. Acreage under potato crop as a share of total tillage acreage in 1844 is also included to allow baronies similarly impacted by blight but with different pre-famine levels of potato dependence to experience systematically different changes after 1845. Each regression furthermore includes the outcome variable in the most proximate pre-famine year and all available pre-famine periods to control for possible pre-trends.[15,16] Along these observable dimensions, in Eqs. (2.1) and (2.2), baronies differentially afflicted by blight are allowed to experience systematically different changes after 1845. The identification assumption is that baronies with different blight infection rates but similar pre-famine characteristics would have changed the same after 1845 if not for blight.

Several additional estimation details are worth noting. First, regressions for livestock outcomes are subdivided by farm size to allow for average

[15] Though the main sample of blight severity includes 255 observations, the number of observations for all regressions is less than 255. This owes to the fact that baronies missing pre-famine observations of included outcome and control variables are automatically excluded.

[16] Data limitations do not permit the inclusion of pre-famine observations of farm size and livestock holdings.

effects to differ for different types of farms.[17] Second, the outcome years analyzed are selected so as to, where possible, estimate average effects 1, 5, 10, 20, and 40 years after the end of the famine in 1851. Where it is possible to analyze outcomes between 1845 and 1851—in other words, during the famine years—I do so. Third, standard errors are clustered at the baronial level (PLU level for estimations of Eq. 2.2) to adjust for heteroskedasticity and within-barony or within-PLU correlation over time.

2.3 Results

To illustrate the empirical framework and analysis, results from estimating Eqs. (2.1) and (2.2) are presented in Fig. 2.1. Panels A through D graph estimated coefficients ($\beta_{1,2t}$'s and β_t's) from Eqs. (2.1) and (2.2), representing differences in changes in the indicated outcome variable in high- or medium-impact baronies or medium- to high-impact PLUs relative to low-impact baronies or low- to medium-impact PLUs. Panels E and F graph estimated coefficients representing differences in changes in cattle and poultry holdings in high-impact baronies relative to low-impact baronies, subdivided by farm size. I find that, in the short and medium runs, increases in buffer livestock holdings of poultry constituted a major response to blight for small farms of less than 5 acres. Demographic change and decreases in the percentage of farms of less than 1 acre were significant short- to medium-run margins of adjustment. Crop diversification occurred primarily over the medium run, while substitutions toward grazing livestock, particularly cattle and sheep, took place only in the long run and were concentrated among medium-sized farms of 5–30 acres. I find no statistically significant differential changes in livestock holdings for farms of more than 30 acres in worse versus less infected baronies.

[17] Available data do not allow us to distinguish average changes in population and crop acreage by farm size.

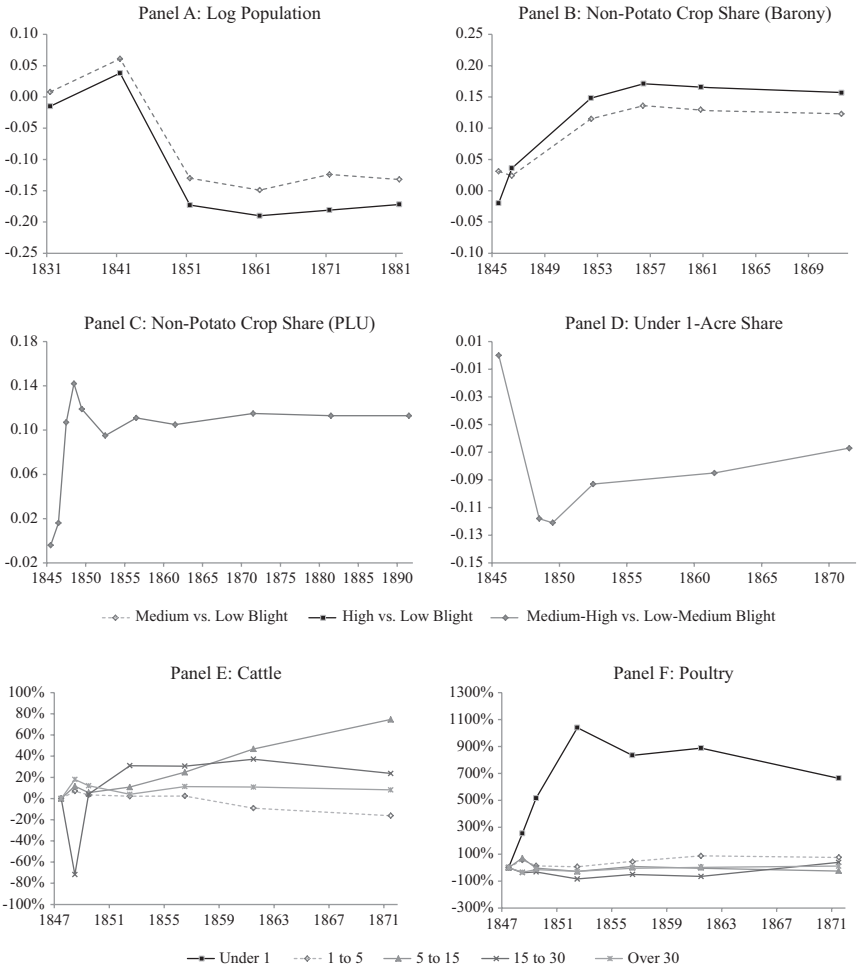

Fig. 2.1 Estimated changes by blight severity (Notes: Panels A through D graph estimated coefficients ($\beta_{1,2t}$'s and β_t's from Eqs. (2.1) and (2.2) in the text) representing differences in changes in the indicated outcome variable in high- or medium-impact baronies or medium- to high-impact PLUs relative to low-impact baronies or low- to medium-impact PLUs, respectively. For illustrative purposes, in Panels B and C, I reverse the sign on the estimated coefficients for blight severity so as to present estimated relative changes in the fraction of total tillage acreage not under potato crop. Panels E and F graph estimated coefficients representing differences in changes in cattle and poultry holdings in high-impact baronies relative to low-impact baronies, subdivided by farm size. Panel E excludes estimated coefficients for farms under 1 acre because the absolute cattle numbers are small and thus the estimated coefficients highly volatile and statistically insignificant)

2.3.1 Short and Medium Runs

Changes in buffer livestock holdings, especially poultry, were a significant short-run response to blight by small farms. Table 2.1 reports estimates of Eq. (2.1) for percentage changes in the total number of poultry, subdivided by farm size. Unfortunately, livestock data are only available from 1847, so differenced estimates are of changes in livestock holdings from levels observed during the third and worst year of the famine and therefore reflect relative recovery and adaptation from the famine's nadir, rather than variation in outcomes during the critical 1845–47 period.[18]

In the years immediately following 1847, small farms in baronies experiencing severe or considerable blight infection in 1845 and 1846 substantially increased holdings of poultry relative to small farms in baronies experiencing only moderate infection. Columns 1 and 2 of Table 2.1 report that in the year following "Black '47," smaller than in baronies experiencing severe or considerable infection had increased aggregate poultry stocks by 253.7 and 126.3 percentage points more than farms of less than 1 acre in baronies experiencing only moderate infection. By the end of the famine, in 1852, smaller than in severely and considerably impacted baronies had increased poultry stocks by 1039.6 and 737.8 percentage points more, respectively, than farms under 1 acre in moderately infected baronies. The estimated coefficients show these differential changes in poultry stocks persisting through the medium run. In 1856, five years after the end of the famine, relative increases in poultry by farms under 1 acre were still 834.3 and 448.4 percentage points larger in severely and considerably impacted baronies than in moderately impacted baronies.[19]

[18] If livestock data were available for 1845 and 1846, we would expect to observe large sell-downs of livestock assets in 1846 and 1847, particularly by small farms. Unfortunately, available data allow us to analyze only differential responses after the worst of the famine was already over and thus presumably reflect both rebuilding of depleted livestock holdings and expansion of precautionary buffer stocks.

[19] To place these percentages in perspective, farms of less than 1 acre in severely infected baronies held a total of 77,009 chickens in 1847, or 2.79 per farm, representing just 3.1% of total poultry holdings of 2,446,034 in those baronies. Estimated coefficients for 1848 imply that, one year on from the worst year of the famine, farms of under 1 acre in severely infected baronies had *relatively* increased aggregate poultry stocks by 194,833 more chickens, or 10.03 chickens per farm in 1848, than farms of under 1 acre in only moderately infected baronies. Per-farm relative increases were

Relative increases in aggregate poultry stocks were also a significant short-run response by farms of 1–5 and 5–15 acres. Estimated coefficients reported in columns 3 through 6 of Table 2.1 indicate that in 1848, farms of between 1 and 5 acres in baronies experiencing severe or considerable infection increased aggregate poultry stocks by 56.6 and 31.0 percentage points more than 1- to 5-acre farms in baronies experiencing only moderate infection, with corresponding differential changes of 71.1 and 36.6 percentage points for farms of 5–15 acres. By 1849, however, the differential changes appear to have dissipated. Estimated coefficients reported in columns 7 through 10, meanwhile, reveal some statistically significant differences in average changes in aggregate poultry stocks for farms of 15–30 acres in severely and considerably infected baronies relative to farms of 15–30 acres in moderately impacted baronies. The signs, however, are negative, suggesting that sales of poultry by medium-to-large farms to smaller farms may have played a role in short-run recovery from and adjustment to blight.

Pig stocks also appear to have constituted a short- to medium-run margin of adjustment for small- to medium-sized farms of 1–15 acres, though not for farms of less than 1 acre. Estimated coefficients reported in columns 3 through 6 of Table 2.2 indicate that by 1852, farms of between 1 and 5 acres in baronies experiencing severe or considerable infection had increased aggregate pig stocks by 121.5 and 32.3 percentage points more, respectively, than 1–5 acre farms in baronies experiencing only moderate infection, with corresponding differential changes of 142.5 and 77.4 percentage points for farms of 5–15 acres. As with poultry stocks, estimated coefficients reported in column 7 suggest that relative increases in pig stocks by farms of 1–15 acres in severely infected baronies may have been achieved in part by sell-downs of pig stocks by farms of 15–30 acres in those baronies. Changes in other livestock holdings do not appear to have constituted short-run responses to blight. During the famine years, there were no consistently statistically significant changes

probably closer to eight chickens, however, as the number of farms less than 1 acre decreased by 17% between 1847 and 1848 in moderately infected baronies relative to severely infected baronies, the latter presumably having already witnessed greater declines in the number of farms under 1 acre in 1846 and 1847.

Table 2.1 Estimated changes in poultry holdings by blight severity

	Under 1 acre		*1 to 5 acres*		*5 to 15 acres*		*15 to 30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	2.537**	1.263**	0.566*	0.310*	0.711*	0.366*	−0.375	−0.076	−0.340	−0.084
	(1.12)	(0.61)	(0.31)	(0.19)	(0.37)	(0.22)	(1.10)	(0.72)	(0.40)	(0.21)
1849	5.162**	2.364**	0.134	0.127	−0.034	0.014	−0.319*	−0.062	−0.142	0.024
	(2.37)	(1.06)	(0.28)	(0.19)	(0.20)	(0.16)	(0.17)	(0.11)	(0.10)	(0.08)
1852	10.396*	7.378*	0.066	0.175	−0.282	0.021	−0.840***	−0.172	−0.279	0.069
	(5.30)	(3.75)	(0.42)	(0.29)	(0.29)	(0.23)	(0.30)	(0.26)	(0.25)	(0.18)
1856	8.343**	4.484**	0.466	0.376	0.085	0.244	−0.503	0.061	−0.048	0.159
	(4.20)	(2.09)	(0.48)	(0.37)	(0.35)	(0.27)	(0.38)	(0.32)	(0.31)	(0.23)
1861	8.875	6.592	0.88	0.714*	−0.050	0.176	−0.653	−0.056	0.016	0.122
	(7.57)	(7.17)	(0.59)	(0.41)	(0.37)	(0.30)	(0.41)	(0.33)	(0.30)	(0.20)
1871	6.638	2.518	0.755	0.616	−0.253	0.163	0.393	0.426	0.115	0.125
	(4.81)	(2.13)	(0.83)	(0.57)	(0.48)	(0.42)	(1.08)	(0.58)	(0.49)	(0.34)
N	202		202		202		202		202	
R2	0.166		0.172		0.238		0.361		0.380	

Notes: Each column reports estimated coefficients ($\beta_{1,2t}$'s and β_t's from Eqs. (2.1) and (2.2) in the text) for changes in the number of poultry, subdivided by farm size, in the indicated year by blight severity. All regressions control for area, population, potato crop share of total tillage acreage, partial adult literacy, baronial valuation, the share of housing rated fourth class, farm size distribution in 1847, and PLU and county controls. Robust standard errors are reported in parentheses and are clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 2.2 Estimated changes in pig holdings by blight severity

	Under 1 acre		*1 to 5 acres*		*5 to 15 acres*		*15 to 30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	3.585	1.647	0.254	−0.081	0.555***	0.218	−0.236	−0.121	0.084	0.117
	(3.39)	(1.79)	(0.30)	(0.27)	(0.21)	(0.19)	(0.94)	(0.61)	(0.17)	(0.14)
1849	0.781	0.646	0.709*	0.017	0.881***	0.457*	−0.941**	−0.471	−0.079	0.081
	(1.33)	(0.82)	(0.41)	(0.35)	(0.26)	(0.24)	(0.44)	(0.31)	(0.33)	(0.22)
1852	−1.928	−1.598	1.215**	0.323	1.425***	0.774*	0.932	0.824	−0.336	0.196
	(5.40)	(3.43)	(0.53)	(0.50)	(0.45)	(0.42)	(0.62)	(0.50)	(0.56)	(0.36)
1856	2.423	1.146	0.848**	0.209	1.364***	0.883**	0.557	0.689	0.100	0.268
	(4.97)	(2.41)	(0.36)	(0.35)	(0.45)	(0.40)	(0.55)	(0.56)	(0.32)	(0.34)
1861	5.113	1.190	−0.020	−0.696	1.242**	1.221**	0.014	0.926	−0.083	0.379
	(7.06)	(3.51)	(1.00)	(1.21)	(0.59)	(0.52)	(0.88)	(0.87)	(0.38)	(0.39)
1871	−2.721	−3.402	0.677	0.170	0.940	1.749	0.902	1.234	0.137	0.523
	(8.76)	(5.54)	(1.58)	(1.67)	(1.10)	(1.11)	(1.13)	(1.15)	(0.79)	(0.81)
N	202		202		202		202		202	
R2	0.131		0.142		0.277		0.274		0.272	

Notes: Each column reports estimated coefficients for changes in the number of pigs, subdivided by farm size, in the indicated year by blight severity. All regressions control for area, population, potato crop share of total tillage acreage, partial adult literacy, baronial valuation, the share of housing rated fourth class, farm size distribution in 1847, and PLU and county controls. Robust standard errors are reported in parentheses and are clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

in aggregate holdings of horses, mules, asses, goats (not displayed), cattle (Table 2.3), or sheep (Table 2.4) by farms of any size.

Another way to view this margin of adjustment is to estimate average changes in the total value of buffer livestock holdings (poultry and swine) and grazing livestock (cattle, sheep, and goats). To condense reported results and reduce noise for average changes, estimated coefficients are pooled across some later time periods, and I estimate average changes for small- and medium-sized farms of up to 15 acres, and large farms of over 15 acres. Results are presented in Table 2.5. In the years immediately following 1847, farms under 15 acres in baronies experiencing severe or considerable blight infection in 1845 and 1846 substantially increased the value of holdings of buffer stocks of poultry and swine relative to farms under 15 acres in baronies experiencing only moderate infection. Panel A, columns 1 and 2 of Table 2.5, show that in the year following "Black '47," farms of less than 15 acres in baronies experiencing severe or considerable infection had increased buffer stock holdings by non-statistically significant £158.60 and £33.37 more than farms of less than 15 acres in baronies experiencing only moderate infection. By the end of the famine, in 1852, farms under 15 acres in high- and medium-blight baronies had increased buffer stocks by £486.33 and £316.01 more, respectively, than farms under 15 acres in low-blight baronies.

In contrast, estimated coefficients reported in Panel B, columns 1 and 2 of Table 2.5, indicate that through 1852, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies did not experience systematically different changes in the value of holdings of grazing livestock (cattle, sheep, and goats). Meanwhile, estimated coefficients reported in Panels A and B, columns 3 and 4 of Table 2.5, reveal that in both the short and medium runs, farms over 15 acres in high- and medium-blight baronies did not experience systematically different changes in either the value of buffer livestock holdings or the value of holdings of grazing livestock, relative to farms over 15 acres in low-blight baronies.

Crop substitutions were a sticky medium-run margin of adjustment, with substantial substitutions occurring only after two successive years of blight. Columns 5 through 7 of Table 2.6 report estimates of Eqs. (2.1) and (2.2) for changes in the potato crop's share of total tillage acreage,

Table 2.3 Estimated changes in cattle holdings by blight severity

	Under 1 acre		*1 to 5 acres*		*5 to 15 acres*		*15 to 30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	0.573	0.660	0.070	0.088	0.117	0.120*	−0.718	−0.353	0.180	0.132
	(0.69)	(0.60)	(0.08)	(0.08)	(0.07)	(0.07)	(1.89)	(1.24)	(0.16)	(0.10)
1849	0.629	0.745	0.035	0.088	0.056	0.051	0.041	−0.037	0.121**	0.106**
	(1.35)	(1.05)	(0.13)	(0.15)	(0.09)	(0.09)	(0.11)	(0.11)	(0.06)	(0.05)
1852	0.665	0.547	0.022	0.002	0.108	0.108	0.310	0.133	0.040	0.064
	(1.18)	(0.88)	(0.16)	(0.16)	(0.10)	(0.10)	(0.22)	(0.18)	(0.16)	(0.16)
1856	0.268	0.208	0.024	0.068	0.248**	0.227**	0.306	0.246	0.113	0.143
	(0.26)	(0.16)	(0.14)	(0.15)	(0.12)	(0.11)	(0.19)	(0.18)	(0.18)	(0.18)
1861	−1.336	−1.008	−0.091	0.017	0.468***	0.273***	0.372	0.187	0.108	0.114
	(1.16)	(0.79)	(0.13)	(0.15)	(0.14)	(0.10)	(0.27)	(0.22)	(0.16)	(0.16)
1871	0.716*	0.396	−0.162	−0.037	0.747***	0.309*	0.237	0.085	0.082	0.111
	(0.43)	(0.28)	(0.15)	(0.16)	(0.27)	(0.17)	(0.50)	(0.40)	(0.24)	(0.24)
N	202		202		202		202		202	
R2	0.127		0.161		0.359		0.647		0.589	

Notes: Each column reports estimated coefficients for changes in the number of cattle, subdivided by farm size, in the indicated year by blight severity. All regressions control for area, population, potato crop share of total tillage acreage, partial adult literacy, baronial valuation, the share of housing rated fourth class, farm size distribution in 1847, and PLU and county controls. Robust standard errors are reported in parentheses and are clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 2.4. Estimated changes in sheep holdings by blight severity

	Under 1 acre		*1 to 5 acres*		*5 to 15 acres*		*15 to 30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	0.997	0.266	–0.440	–0.157	–0.714	–0.495	0.185	0.191	–1.380	–0.575
	(0.79)	(0.58)	(0.490)	(0.47)	(0.94)	(0.70)	(0.13)	(0.14)	(2.64)	(1.78)
1849	–2.164	2.893	0.398	0.490	–1.024	–0.763	–1.844	–1.793	–0.073	–0.016
	(2.35)	(2.20)	(0.35)	(0.33)	(0.76)	(0.75)	(1.77)	(1.79)	(0.14)	(0.14)
1852	–3.668	0.124	–0.731	–0.686	–1.624	–0.888	0.602	0.049	–0.305	–0.147
	(5.16)	(1.27)	(0.99)	(0.980)	(1.13)	(1.20)	(0.42)	(0.39)	(0.42)	(0.41)
1856	0.089	0.466	–2.468	–1.892	–0.931	–0.980	0.852	0.513	–0.199	–0.005
	(0.35)	(0.33)	(1.66)	(1.67)	(1.14)	(1.10)	(0.53)	(0.38)	(0.46)	(0.46)
1861	0.372	0.230	–0.132	0.143	–1.336	–1.073	1.555*	0.345	–0.401	0.016
	(0.41)	(0.36)	(0.53)	(0.54)	(1.21)	(1.22)	(0.93)	(0.75)	(0.53)	(0.49)
1871	–6.298	1.990	–0.751	–0.435	–0.332	–0.233	1.517*	0.617	0.161	0.252
	(8.11)	(2.01)	(0.91)	(0.97)	(1.02)	(0.97)	(0.88)	(0.69)	(0.66)	(0.67)
N	202		202		202		202		202	
R2	0.070		0.086		0.308		0.161		0.399	

Notes: Each column reports estimated coefficients for changes in the number of sheep, subdivided by farm size, in the indicated year by blight severity. All regressions control for area, population, potato crop share of total tillage acreage, partial adult literacy, baronial valuation, the share of housing rated fourth class, farm size distribution in 1847, and PLU and county controls. Robust standard errors are reported in parentheses and are clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 2.5 Estimated changes in the value of livestock holdings by blight severity

	Farms under 15 acres		*Farms over 15 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)
A. Buffer livestock				
1848	158.599	33.374	449.315	373.164
	(132.63)	(128.47)	(464.80)	(461.94)
1849	350.518**	209.041	558.746	447.785
	(164.89)	(159.06)	(767.55)	(757.67)
1850	388.594***	302.074**	441.436	307.514
	(139.95)	(139.34)	(669.28)	(661.85)
1852	486.334**	316.014*	395.912	138.931
	(192.56)	(186.57)	(466.87)	(459.62)
1856–61	446.712**	254.276	40.965	–267.275
pooled	(200.68)	(186.67)	(256.23)	(253.13)
1866–71	441.113**	386.286*	–600.703*	–610.985
pooled	(211.47)	(207.13)	(362.88)	(375.91)
B. Grazing livestock				
1848	–844.649	–985.818	–532.691	–941.168
	(731.92)	(767.02)	(1984.14)	(1996.07)
1849	–602.019	–1016.016	3042.417	1971.669
	(710.60)	(710.62)	(2367.57)	(2329.31)
1850	–799.001	–1441.944	5962.488	2401.637
	(1022.63)	(957.34)	(4257.10)	(4251.43)
1852	–222.783	–965.271	–618.859	–2958.315
	(1184.76)	(1121.25)	(4717.51)	(4734.08)
1856–61	2185.902*	1048.688	1220.529	–2044.959
pooled	(1245.66)	(1064.01)	(4248.64)	(4246.38)
1866–71	2159.983*	1088.665	2061.827	–1957.519
pooled	(1260.63)	(1166.33)	(5083.81)	(5136.33)
N	202		202	
R2	0.296 (A) 0.157 (B)		0.490 (A) 0.503 (B)	

Notes: Each column reports estimated coefficients for changes in the value of holdings of buffer (swine and poultry) livestock (Panel A) and grazing (cattle, sheep, and goats) livestock (Panel B), subdivided by farm size, in the indicated year by blight severity. All regressions control for area, partial adult literacy in 1841, 1841 population, pre-famine baronial valuation, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, and PLU and county. Estimated coefficients are pooled across the years 1856–61 and 1866–71. Robust standard errors are reported in parentheses and are clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

first differenced from the potato crop share in 1845, that is, $Y_{bt=0} = Y_{b1845}$, the last crop planted before the arrival of blight.[20] The estimated coefficients reported in columns 5 and 6 show that between 1845 and 1846, baronies experiencing severe or considerable blight infection increased the non-potato crop share of total tillage acreage by 3.6 and 2.8 percentage points more than moderately impacted baronies. Columns 5 and 6 also indicate that by 1852, severely and considerably impacted baronies had reduced the potato's share of total crop acreage by 14.8 and 11.5 percentage points more than moderately impacted baronies. Crop substitutions continued through the medium run, with the cumulative reduction in the share of acreage under potato crop rising to 17.1 and 13.6 percentage points more in severely and considerably impacted baronies by 1856, relative to moderately impacted baronies.

Column 7 of Table 2.6 reports estimates of Eq. (2.2) for relative changes in the share of total tillage acres under potato crop after 1845.[21] Estimated coefficients indicate that the fraction of total crop acreage allocated to potato cultivation in medium- to high-impact PLUs was only substantially reduced after two successive potato crop failures. While PLUs suffering medium to high blight infection in 1845–46 only increased the fraction of total tillage acreage allocated to other crops in 1846 by a nonstatistically significant 1.6 percentage points more than lesser affected PLUs, by 1847, PLUs that had suffered higher infection rates in the preceding two years increased the non-potato share of total

[20] These results must be treated with considerable caution, as official published statistics on potato crop acreages do not exist prior to 1847. The 1844–46 figures used here are thus estimates compiled by the late Irish economic historian Austin Bourke from constabulary reports. See Bourke (1960, 1965b). Mokyr (1985) and Solar (1987) argue that Bourke's estimates are likely too high. However, their criticisms focus on Bourke's aggregation method and possible conflation of figures ambiguously quoted in Irish or statute acres. By keeping the data disaggregated, the first objection does not apply here. Further, my analysis focuses on relative changes in potato acreage, rather than absolute levels, which means that so long as quotation in Irish or statute acres was uncorrelated with blight severity, the choice of unit is irrelevant. Finally, the estimated coefficients on blight severity for 1846 must be considered merely indicative, as my blight severity index consists mostly of observations made in 1846. However, inasmuch as observations from late 1845 and early 1846 are included, the results are roughly informative.

[21] Sample size is limited by the fact that pre-famine farmholding data at the PLU level include only 130 PLUs, among which I have blight observations for 99. Sample size is then further reduced by lack of pre-famine valuation data for all PLUs and by the fact that several PLUs are missing data from the 1848–1850 agricultural surveys.

Table 2.6 Estimated changes in population, potato crop share, and farm size by blight severity

	Population (logs)		Population (levels)		Potato crop share			Farm size		
								<1 acre	*1–5 acre*	*<5 acres*
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Med–high vs. low–med	Med–high vs. low–med		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1846					−0.036***	−0.024**	−0.016			
					(0.01)	(0.01)	(0.02)			
1847							−0.107*			
							(0.06)			
1848							−0.142**	−0.109**	−0.036	−0.145**
							(0.06)	(0.05)	(0.04)	(0.06)
1849							−0.119*	−0.100**	−0.034	−0.134**
							(0.07)	(0.05)	(0.04)	(0.06)
1851	−0.173***	−0.130***	−7004.299***	−4698.786***						
	(0.06)	(0.04)	(2305.04)	(1401.03)						
1852					−0.148***	−0.115***	−0.095*	−0.082**	−0.003	−0.085*
					(0.05)	(0.04)	(0.05)	(0.04)	(0.03)	(0.05)
1856					−0.171***	−0.136***	−0.111**			−0.067
					(0.05)	(0.04)	(0.05)			(0.05)
1861	−0.190***	−0.149***	−7030.509**	−5091.797**	−0.165***	−0.128***	−0.105**	−0.078*	0.020	−0.058
	(0.07)	(0.05)	(3178.34)	(1972.81)	(0.05)	(0.05)	−0.05	(0.04)	(0.03)	(0.05)
1871	−0.181***	−0.124***	−7360.487**	−4809.293**	−0.157***	−0.123***	−0.115**	−0.066	0.016	−0.051
	(0.05)	(0.04)	(3519.63)	(2205.39)	(0.05)	(0.04)	−0.05	(0.04)	(0.03)	(0.05)
1891	−0.172**	−0.132**	−7859.179*	−5002.676*			−0.113**			
	(0.08)	(0.05)	(4088.44)	(2536.49)			(0.05)			
N	188		188		206		93	93	93	93
R2	0.660		0.671		0.477		0.119	0.224	0.212	0.113

Notes: Each column reports estimated coefficients for changes in log population, the fraction of total tillage acres under potato crop, and the fraction of all farmholdings measuring under 1 acre, between 1 and 5 acres, and under sacres in the indicated year by blight severity. Baronial-level regressions control for available pre-famine observations of outcome variables, area, partial adult literacy in 1841, pre-famine baronial valuation, the share of housing rated fourth class, and PLU and county. PLU-level regressions control for available pre-famine outcome variable observations, area, pre-famine valuation, and county. Robust standard errors are reported in parentheses and are clustered at the baronial or PLU level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

tillage acreage by a statistically significant 10.7 percentage points more than low- to medium-impact PLUs. Column 7 also reports that the reduction in the share of total tillage acreage under potato crop in 1848 and 1849 was 14.2 and 11.9 percentage points greater, respectively, in medium- to high-impact PLUs than in low- to medium-impact PLUs.

Demographic change and related changes in the patterns of landholding appear to have constituted significant short- to medium-run margins of adjustment to blight.[22] Columns 1 and 2 of Table 2.6 report estimates of Eq. (2.1) for changes in the log of total population in the indicated year, with $Y_{bt=0} = Y_{b1841}$. Estimated coefficients show that, relative to moderately impacted baronies, baronies that were severely or considerably affected by blight in 1845 and 1846 experienced population declines that were 17.3% and 13.0% greater between the censal years 1841 and 1851.[23] Columns 3 and 4 report estimates for changes in population levels, with estimated coefficients revealing that severely and considerably infected baronies experienced population declines that were greater by 7004.299 and 4698.786 persons respectively, between the censal years 1841 and 1851.

A reduction in the fraction of farms under 1 acre was also a short-run result of blight. Estimates of Eq. (2.2) for changes in the share of total farmholdings under 1 acre and between 1 and 5 acres are reported in columns 8 and 9 of Table 2.6. The estimated coefficients indicate that the decline in the fraction of all farmholdings under 1 acre was 10.9 percentage points greater between 1845 and 1848 in medium- to high-impact PLUs than in low- to medium-impact PLUs. By the end of the famine, the under-1-acre share of all farmholdings was 8.2 percentage

[22] Unfortunately, available data do not allow us to distinguish between changes in population owing to net out-migration versus excess mortality, though presumably the relative contributions of both causes varied with blight severity and time horizon. The cheapest transatlantic steerage fares could be had for as low as £3 or £4, which represented total annual income for almost two-thirds of the Irish population (Ó Gráda and O'Rourke 1997).

[23] While general equilibrium effects cannot be discounted, historical evidence, including county-level emigration statistics, indicates that internal migration during the famine was extremely limited. This owed both to the local nature of the distribution of statutory relief and to the numerous restrictions on rural mobility by local landlords (Cousens 1960b). In the extreme, however, if the entire population decline in severely and considerably infected baronies consisted of migration to moderately infected baronies, then estimated coefficients would be halved. But considering that for Ireland as a whole, emigration was roughly equal to excess mortality, estimated coefficients 25% smaller than those reported seem a plausible extreme lower bound, especially if more severe blight was more likely to result in death or outright emigration than within-country migration.

points lower in worse affected PLUs. Blight severity appears to have had a negative but not statistically significant differential impact on changes in the proportion of farmholdings between 1 and 5 acres during the famine, as shown in column 9. Estimates reported in column 10, however, show that the combined decline in small farms of fewer than 5 acres as a share of all farmholdings was 8.5 percentage points greater in medium- to high-blight PLUs than in low- to medium-blight PLUs.

While calculated differences (not displayed) between estimated coefficients of high versus medium blight infection on changes in population, poultry, pigs, and the value of buffer livestock holdings (by farms of <15 acres) are statistically significant, calculated differences between estimated coefficients of high versus medium infection for average changes in potato crop share are not statistically significant. This suggests that, in the short and medium runs, baronies experiencing severe versus considerable blight infection did not experience systematically different changes in crop acreage allocation, with both diversifying crop portfolios to roughly the same extent and instead responding differentially along the demographic and livestock margins.

2.3.2 Long Run

The results reported in columns 1 through 6 of Tables 2.1 and 2.2 indicate that while in the short run, farms of up to 15 acres in baronies worse affected by blight increased holdings of relatively cheap buffer livestock like poultry and pigs, these differential changes dissipated over the medium to long runs.[24] In the very long run, there were no statistically significant differences in average changes in aggregate poultry or pig stocks for farms up to 15 acres in severely and considerably infected baronies relative to farms up to 15 acres in moderately impacted baronies. This suggests that small farms in worse affected baronies were not

[24] Note that this result is consistent with the expected positive sign of $\partial L_t^*/\partial \sigma_{jt}$ presented in Sect. 2.1.2. In the short run, higher variance in estimates of expected yields will induce larger holdings of buffer livestock. In the long run, however, the farmer learns from past yield data, which implies a decline in $\sigma_{i,jt}$. Optimal investment in buffer livestock will therefore decrease, while at the same time the permanently lower yield and higher yield variance of crop j will in the long run induce conversion of acreage previously allocated to crop j to other crops or to pasture.

simply rebuilding potentially more depleted stocks, but were relatively increasing poultry and pig stocks specifically during the years of particularly new and extreme yield volatility between 1847 and 1856 in a manner consistent with the precautionary buffer function of chickens and pigs. There were also no statistically significant long-run relative changes in aggregate holdings of horses, mules, or asses (not displayed) for farms of any size, suggesting that adjustments in holdings of these livestock did not constitute a long-run response to blight.

Relative changes in holdings of grazing livestock, however, constituted a major long-run margin of adjustment to blight for small- and medium-sized farms of 5–30 acres. Over the medium to long runs, farms of 5–15 acres in worse affected baronies increased aggregate holdings of cattle. Estimated coefficients reported in columns 5 and 6 of Table 2.3 show that in the very long run, farms of 5–15 acres in severely and considerably impacted baronies had increased cattle stocks by 74.7 and 30.9 percentage points more than farms of 5–15 acres in only moderately impacted baronies. In the very long run, farms of 15–30 acres, meanwhile, appear to have substituted toward sheep; estimated coefficients reported in column 7 of Table 2.4 show that by 1871, farms of 15–30 acres in severely impacted baronies had increased aggregate sheep stocks by 151.7 percentage points more than farms of 15–30 acres in moderately impacted baronies.

Again looking at average changes in the value of buffer (poultry and swine) and grazing (cattle, sheep, and goats) livestock holdings among small- and medium-sized farms (<15 acres) and large farms (>15 acres), we observe similar patterns in Table 2.5. Results reported in Panel A, columns 1 and 2 of Table 2.5, reveal that relative increases in buffer livestock holdings of swine and poultry remained an important margin of adjustment through the long run for farms under 15 acres in high-blight baronies, but not for farms under 15 acres in medium-blight baronies. While the increase in the value of buffer livestock holdings by farms under 15 acres in high-blight baronies, relative to farms under 15 acres in low-blight baronies, peaked in 1852, in 1866–71, the cumulative increase in buffer livestock holdings was still £441.11 greater by farms under 15 acres in high-blight baronies relative to farms under 15 acres in low-blight baronies. In contrast, relative increases in buffer livestock holdings by farms under 15 acres in medium-blight baronies appear to have dissipated after 1852.

Results reported in Panel B, columns 1 and 2 of Table 2.5, reveal that relative increases in the value of grazing livestock holdings of cattle, sheep, and goats were also a significant margin of adjustment over the long run for farms under 15 acres in high-blight baronies, but not for farms under 15 acres in medium-blight baronies. In 1856–61, farms under 15 acres in high-blight baronies had increased holdings of grazing livestock by £2185.90 more than farms under 15 acres in low-blight baronies, with the relative gap persisting through 1871. Estimated coefficients reported in Panels A and B, columns 3 and 4 of Table 2.5, however, indicate that over the long run, farms over 15 acres in high- and medium-blight baronies did not experience systematically different changes in either the value of buffer livestock holdings or in the value of holdings of grazing livestock, relative to farms over 15 acres in low-blight baronies.

Crop substitutions during and immediately after the famine persisted through the long run, though re-converged slightly from a peak gap in 1848 (at the PLU level), which suggests that there may have been some initial overshooting. Estimated coefficients reported in columns 5 and 6 of Table 2.6 show that after peaking in 1856 (at the baronial level), the cumulative reduction in the share of acreage under potato crop was still 15.7 and 12.3 percentage points greater, respectively, in severely and considerably impacted baronies in 1871 than in moderately impacted baronies. At the PLU level, estimated coefficients reported in column 7 of Table 2.6 reveal that as late as 1891, the cumulative reduction in the share of acreage under potato crop was 11.3 percentage points larger in PLUs suffering medium- to high-blight infection than in those suffering low-to medium-blight infection.

Large relative population declines during the famine also appear to have persisted through the long run. Columns 1 and 2 of Table 2.6 show that while in percentage terms the demographic deficit peaked in 1861, by 1891, the cumulative population decline in severely and considerably impacted baronies still exceeded that in moderately impacted baronies by an estimated 17.2% and 13.2%, respectively. Columns 3 and 4 report estimates for changes in population levels, with estimated coefficients revealing that severely and considerably infected baronies experienced long-run population declines that were greater by 7859.179 and 5002.676 persons by 1891.

Meanwhile, differential relative changes in farm size distribution during the famine appear to have dissipated over the long run. Estimated coefficients reported in columns 8 and 9 of Table 2.6 show that though the relative reduction in the proportion of farmholdings under 1 acre remained 7.8 percentage points larger in 1861 in PLUs suffering medium- to high-blight infection relative to low- to medium-impacted PLUs, beyond 1861, there was no statistically significant relative change. Estimates reported in column 10 similarly show that there was no very-long-run combined decline in the proportion of farmholdings under 5 acres in medium- to high-blight PLUs versus in low- to medium-blight PLUs.

As in the short and medium runs, while calculated differences (not displayed) between estimated coefficients of high versus medium blight infection on changes in population, cattle, sheep, and the value of grazing livestock (among farms <15 acres) are statistically significant, calculated differences in estimated coefficients of high versus medium blight infection on average changes in potato crop share are not. This suggests that, in the long run, baronies experiencing considerable versus severe blight infection did not experience systematically different changes in crop acreage allocation, but instead responded differentially by converting acreage from tillage to pasture. In other words, beyond moderate blight infection, baronies more severely infected diversified their crop portfolios to roughly the same extent, with differential adjustments occurring instead through more fundamental changes in land use, namely, the switch from tillage to pasture.

2.4 Conclusion

Initial short- to medium-run responses to blight, in the form of greater accumulations of buffer livestock assets and demographic decline, were eventually superseded in the medium and long runs by changes in land use, namely, substitutions away from the potato toward other tillage crops and pasture. Thus, while proto capital markets and labor were much more flexible in the short and medium runs, land was for the most part initially fixed, with fundamental changes in land use occurring only over the long run. Access to microcredit from the Irish Loan Funds was

an important factor in enabling non-demographic adjustment to adverse environmental shock.

In the short to medium runs, districts that were severely or considerably afflicted by blight in the first two years of the famine experienced 17.3% and 13.0% larger population declines by 1851 than did moderately affected regions, with consistent gaps of 17.2% and 13.2% persisting even 40 years after the end of the famine. By the end of the famine, the fraction of all farmholdings under 1 acre had declined by 8.2 percentage points more in worse affected PLUs. Blight furthermore immediately affected patterns of livestock holding. In the short run, relative to small farms of up to 15 acres in moderately impacted baronies, small farms in baronies suffering severe or considerable blight infection in 1845 and 1846 significantly increased stocks of chickens and pigs—traditional income buffers in the event of crop failure—while the largest farms (over 30 acres) experienced no systematically different changes in livestock holdings, and medium- to large-sized farms (15–30 acres) may even have reduced pig and poultry stocks.

In the medium and long runs, however, worse affected baronies effected larger substitutions toward other tillage crops and grazing livestock. Relative to lesser impacted areas, districts that were worse affected by blight substantially and permanently converted acreage under potato cultivation to other crops, though did so only after two successive crop failures. While PLUs suffering medium- to high-blight infection increased the fraction of total tillage acreage allocated to other crops in 1846 only by 1.6 percentage points more than lesser affected PLUs, by 1847, PLUs that had suffered higher infection rates in the preceding two years increased the non-potato share of total crop acreage by 10.7 percentage points more than lesser impacted PLUs. In the long run, worse affected PLUs are estimated to have effected a permanent 11-percentage point relative reduction in the potato's share of total crop acreage. Long-run acreage reallocation to pasture by medium-sized farms was also significant; by 1871, farms of 5–15 acres in severely affected baronies had increased cattle stocks by 74.7 percentage points more than 5- to 15-acre farms in moderately affected baronies, while farms of 15–30 acres in severely affected baronies increased sheep holdings by 151.7 percentage points more than 15- to 30-acre farms in moderately affected baronies.

2.5 Appendix 2.1

The farmer now maximizes $\pi(\psi, \Sigma)$, where

$$\psi \equiv \psi_{it} A_{it} + \psi_{jt}\left(\bar{A} - A_{it}\right) + \left(p_{Lt} - c_{Lt}\right) L_t$$

and

$$\Sigma \equiv \left(\lambda_i^2 + \sigma_{it}^2\right) A_{it}^2 + \left(\lambda_j^2 + \sigma_{jt}^2\right)\left(\bar{A} - A_{it}\right)^2 + 2A_{it}\left(\bar{A} - A_{it}\right) \times \left(\lambda_i^2 + \sigma_{it}^2\right)\left(\lambda_j^2 + \sigma_{jt}^2\right)\rho_{ij}$$

For $A_{it} > A_{it-1}$, we have first-order conditions

$$\frac{\partial \pi}{\partial A_{it}} = \pi_\psi(\psi_{it} - \psi_{jt}) + 2\pi_\Sigma((\lambda_i^2 + \sigma_{it}^2)A_{it} - (\lambda_j^2 + \sigma_{jt}^2)(\bar{A} - A_{it}) + (\bar{A} - 2A_{it})(\lambda_i + \sigma_{it})(\lambda_j + \sigma_{jt})\rho_{ij}) = 0$$

$$\frac{\partial \pi}{\partial L_t} = \pi_\psi(p_{Lt} - c_{Lt}) = 0$$

Using substitution and solving for $\hat{A}_{it}^*$ and L_t^*, we find that for $\hat{A}_{it}^* > A_{it-1}$, the derivative of L_t^* with respect to σ_{jt} is

$$\frac{\partial L_t^*}{\partial \sigma_{jt}} = \pi_\psi\left(\left(p_{Lt} - c_{Lt}\right) - \left(\psi_{it} - \psi_{jt}\right)\right) + 2\sigma_{jt}\bar{A}\pi_\Sigma\left(\operatorname{cov}\left(\eta_{it}, \eta_{jt}\right) - \lambda_i^2 - \sigma_{it}^2\right) + \left(\frac{\left(c_{it} - c_{jt}\right)}{c_{Lt}\pi_\Sigma\left(\left(\lambda_i^2 + \sigma_{it}^2\right) + \left(\lambda_j^2 + \sigma_{jt}^2\right) - 2\operatorname{cov}\left(\eta_{it}, \eta_{jt}\right)\right)^2}\right)$$

By the assumption of risk aversion ($\pi_\Sigma < 0$), the common denominator is negative, which means, provided $c_{jt} < c_{it}$, if $0 > \partial L_t^* / \partial \sigma_{jt}$, then

$$\pi_\Sigma < \frac{\pi_\psi \left(\left(\psi_{it} - \psi_{jt} \right) - \left(p_{Lt} - c_{Lt} \right) \right)}{2\sigma_{it} \bar{A} \left(\operatorname{cov}\left(\eta_{it}, \eta_{jt} \right) - \left(\lambda_i^2 + \sigma_{it}^2 \right) \right)}$$

As long as $\sigma_{it}^2 > 0$, the denominator of this expression is always negative. The numerator, which represents the difference in the marginal net benefit between crop i and livestock holding, we can assume, is positive, as otherwise the farmer should have no incentive to cultivate a risky crop i versus raising assumed zero-risk livestock. Thus, the right-hand side of the aforementioned expression is negative, consistent with the assumption of risk aversion ($\pi_\Sigma < 0$).

The derivative of L_t^* with respect to λ_j can be obtained analogously, with $\partial L_t^* / \partial \lambda_j > 0$ if

$$\pi_\Sigma < \frac{\pi_\psi \left(\left(\psi_{it} - \psi_{jt} \right) - \left(p_{Lt} - c_{Lt} \right) \right)}{2\sigma_{it} \bar{A} \left(\operatorname{cov}\left(\eta_{it}, \eta_{jt} \right) - \left(\lambda_i^2 + \sigma_{it}^2 \right) \right)}$$

3

Credit and Adaptation

> To the labourer the Loan Fund is invaluable, as affording capital for the annual purchase of his pig. The low wages obtained by this class put it almost out of their power to save a sufficient sum for this purpose, without being tempted by their continual necessity to encroach upon it. Charles Piesse, *Sketch of the Loan Fund System in Ireland* (1841)

Building on the theoretical framework and empirical approach of Chap. 2, in this chapter, I examine the role of credit institutions in facilitating non-demographic agricultural adjustment to the shock of the famine, asking how relative marginal adjustments differed where one binding constraint—access to small-loan credit—was at least partially relaxed. The empirical analysis is therefore based on estimating average relative changes for more severely infected baronies with a Loan Fund versus those without, in the same county and PLU and with similar pre-famine characteristics.

I find that microfinance lending by the Irish Loan Funds played a significant role in non-demographic adjustment to blight, especially for small- to medium-sized farms. The presence of at least one Loan Fund in a severely affected barony between 1845 and 1851 was associated with a

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42.1% smaller *relative* population decline by 1851.[1] Loan Fund lending appears both to have enabled earlier crop substitutions away from the potato and the maintenance of larger buffer livestock holdings during and immediately after the famine. Specifically, by 1852, small farms of 1 to 5 acres in severely affected baronies with a Loan Fund had increased pig and poultry holdings by 133 and 82 percentage points more, respectively, than 1–5-acre farms in baronies without a fund, relative to comparably sized farms in moderately affected baronies. Long-run adaptation through relative increases in holdings of grazing livestock by medium-sized farms of 5–15 acres was also greater in severely infected baronies with a Loan Fund versus those without. To address potential selection bias in the location of microloan funds, I use an instrumental variables strategy that exploits the unique historical origins of these funds. Since the first Loan Fund was established by the Dublin Musical Society, which for a brief time then operated a loosely affiliated branch system of musical loan societies, in robustness checks, I use the location of Association of Irish Musical Societies' (AIMS) member organizations to instrument for the location of Loan Funds.

The results of this chapter do not challenge more traditional explanations of the Great Famine and the spatial spread of famine intensity (McGregor 1984; Ó Gráda 1999). Rather, controlling for such variables, I demonstrate how relative marginal adjustments differed where, holding constant the severity of the environmental shock, one binding constraint was partially relaxed. Analyzing a shock of the magnitude of the Great Famine allows the econometrician to observe such relative marginal adjustments as may not be observable in studies of less severe environmental events.

3.1 Theoretical Framework

Since Feder (1980), de Janvry et al. (1991), Gine and Klonner (2005), Foster and Rosenzweig (2010), and Kinnan and Townsend (2012) have

[1] It is important to emphasize that this is not the same as a 42.1% smaller absolute population decline. Rather, it means that the *additional* population decline in severely infected baronies *relative* to moderately infected baronies was 42.1% smaller where there was a Loan Fund, versus where there was not.

demonstrated the importance of credit constraints in acreage allocation and consumption smoothing, I build on the model constructed in Chap. 2 by considering the implications of the farmer facing up-front fixed costs to reallocating land from one crop to another, and constrained credit. I assume that whatever portion of the sum of fixed and variable costs exceeds the farmer's wealth at the start of year t, ω_t, he must finance via borrowing; cash expenditure cannot exceed cash availability from initial resources plus credit.[2]

Supposing the cost of converting acreage that had been planted with crop j in $t-1$ to crop i (or vice versa) in year t is a fixed, per-acre outlay k, the rate of interest facing the farmer r, and his credit limit $\bar{K}$, his problem now becomes to maximize $\pi(\psi, \Sigma)$, subject to $\left(\left|A_{it} - A_{it-1}\right| k + c_{it} A_{it} + c_{jt}\left(\bar{A} - A\right)\right) \leq \omega_t + \bar{K}$. In this case, acreage allocated to crop i is still increasing in the profit differential between crops i and j, and decreasing in portfolio variance. Now, however, it is additionally a decreasing function of the cost of conversion, as well as the rate of interest, i.e., $\partial \hat{A}_{it}^{*} / \partial r < 0$, if the marginal cost of crop i (the sum of the cost of conversion and the variable cost of crop i) is greater than the marginal cost of crop j, that is, if $c_{jt} < k + c_{it}$.[3] Assuming the credit constraint is binding,

[2] I have treated wealth, ω_t, as an exogenous constraint, when it is in fact determined by the farmer's choice of precautionary consumption, saving, and investment in the preceding period. His optimization problem is thus a dynamic programing one proceeding in three stages. First, to allocate acreage and initial wealth so as to maximize ψ_t while minimizing volatility. Second, to determine what fraction of realized ψ_t to save versus consume at the end of period t. Third, to determine in which asset classes to invest those savings (cull piles, grain stores, livestock, etc.) so as to maximize his total liquid wealth at the start of period $t + 1$. Most buffer stock models focus on the second and/or third stages. While these constitute important and interesting questions, they are less informative in analyzing situations of extreme environmental shock, especially in subsistence tenant contexts where ω_t may be zero, when the first stage becomes paramount, namely, how to allocate scarce resources at the start of period t, given an uncertain probability of harvest failure. Though a full dynamic model encompassing all three stages, including the farmer's consideration of the relative spoilage, maintenance, and liquidation costs of various alternative assets between the end of period t and start of period $t + 1$, would be illuminating, it lies beyond the scope of this chapter, especially since data on livestock holdings during the most acute years of the famine, when we would expect the transitory shock to wealth to be the first-order effect, are unavailable. The fact that the pigs and poultry were typically purchased with the intention of liquidation during period t is an additional reason why I opt for a mean-variance portfolio optimization approach rather than a dynamic programming model.

[3] For derivation, see Appendix 3.1.

a corner solution will exist at either $\hat{A}_{it}^{*}=0$, if $\frac{\omega_t+\overline{K}+A_{it-1}k-c_{jt}\overline{A}}{k+(c_{it}-c_{jt})}<0$, or $\hat{A}_{it}^{*}=\overline{A}$, if $\overline{A}=\frac{\omega_t+\overline{K}+A_{it-1}k}{k+c_{it}}$, with a decrease (increase) in available credit $\overline{K}$ thus in the latter case clearly decreasing (increasing) $\hat{A}_{it}^{*}$.

Considering buffer livestock assets, I again suppose that in addition to the choice between allocating acreage between two alternative agricultural uses, the farmer can also choose to invest in L_t heads of non-grazing (and therefore non-acreage-consuming) livestock, at a unit price of c_{Lt}, that he can sell during period t for a guaranteed unit price of $p_{Lt} > c_{Lt}$. The farmer now maximizes $\pi(\psi, \Sigma)$, where now

$$\begin{aligned}\psi \equiv{}& \psi_{it}A_{it}+\psi_{jt}\left(\overline{A}-A_{it}\right)+\left(p_{Lt}-c_{Lt}\right)L_t\\ &-r\left(\left|A_{it}-A_{it-1}\right|k+c_{it}A_{it}+c_{jt}\left(\overline{A}-A\right)+c_{Lt}L_t-\omega_t\right)\end{aligned}$$

Essentially, the farmer's challenge is therefore to determine the optimal acreage to allocate to crop i, and the optimal number of buffer livestock to invest in, so as to maximize his net expected return while minimizing total portfolio volatility (formally, his expected utility function is increasing in net expected return and decreasing in total portfolio volatility), and subject to constrained credit.

Optimizing A_{it} and L_t, subject to the credit constraint, we can then evaluate how the farmer's optimal allocation to livestock changes as the various parameters of the model vary.[4] In particular, we are interested in how optimal investment in livestock varies with the cost and supply of credit, estimated yield, and yield volatility. We find that $\partial L_t^{*}/\partial r < 0$ if $c_{Lt} > k + (c_{it} - c_{jt})$ and $c_{jt} < k + c_{it}$, meaning so long as the unit cost of buffer livestock is greater than the marginal cost of converting acreage from crop j to crop i, and the marginal cost of crop i is greater than the marginal cost of crop j, optimal investment in buffer livestock will be decreasing with the cost of credit. Considering volatility, we find that, assuming risk

[4] For derivation, see Appendix 3.2.

aversion, $\partial L_t^*/\partial \sigma_{jt}$, $\partial L_t^*/\partial \lambda_j > 0$.[5] That is, optimal investment in livestock is increasing in the standard deviation of the farmer's estimated yield of crop j and in the standard deviation of the disturbance term of crop j, so any increase in the volatility of crop j's yield will raise optimal buffer livestock holdings. We can also observe that optimal investment in livestock is always increasing in the farmer's available supply of credit, since $\partial L_t^*/\partial \bar{K} = 1/c_{Lt}$, which is always positive.

In the extended model outlined above, the farmer is thus maximizing expected net return (technically, his expected utility is a decreasing function of net yield), minus any costs of converting acreage that has been allocated to crop j over to crop i, minus the cost of borrowing whatever amount of required funds exceeded initial wealth. He is also minimizing total portfolio variance (technically, his expected utility is a decreasing function of net portfolio variance), which includes both true variance and the variance of estimates, as well as covariance of crops i and j. And he is subject to the constraint that his total outlays cannot exceed the sum of his initial wealth and any borrowed capital. The full model predicts that all three primary avenues of non-demographic adjustment derived in Sect. 2.1 of Chap. 2—substitutions toward pasture and other tillage crops, as well as short-run accumulation of buffer livestock—will be impeded by the presence of binding credit constraints.

3.2 Empirical Approach

To evaluate the effect of access to credit, estimates of average changes by Loan Fund activity are then obtained by regressing each differenced outcome in barony b and year t on binary variables for medium- and high-blight severity (B_b^{med} and B_b^{high}), average annual Loan Fund lending from 1845 to 1850 (L_b), the fraction of total baronial border length shared with

[5] $\partial L_t^*/\partial \sigma_{jt}$, $\partial L_t^*/\partial \lambda_j > 0$ if

$$\pi_\Sigma < \frac{\pi_\psi(((\psi_{it}-\psi_{jt})-(1+r)(k+(c_{it}-c_{jt})))-((p_{Lt}-c_{Lt})-(1+r)c_{Lt})}{2\sigma_{it}\bar{A}(\mathrm{cov}(\eta_{it},\eta_{jt})-(\lambda_i^2+\sigma_{it}^2)}$$

So long as $\sigma_{it}^2 > 0$, the denominator in this expression is always negative, while the numerator, which represents the difference in marginal net return between crop i and livestock holding, we can assume, is always positive, as otherwise the farmer should have no incentive to cultivate a risky crop i versus investing in a zero-risk livestock asset.

other baronies with at least one Loan Fund during the famine ($BORD_b$), pre-famine baronial characteristics ($\boldsymbol{X}_b$), categorical variables for county (C_t) and PLU (PLU_t), and an error term (ε_{bt}). Additionally, Loan Fund lending is interacted with blight severity and lags of baronial outcomes ($y_{bt\text{-}n}$):[6,7]

$$Y_{bt} - Y_{bpre} = \beta_{1t}\beta_b^{med} + \beta_{2t}B_b^{high} + \beta_{3t}L_b + \beta_{4t}L_b \times B_b^{med} + \beta_{5t}L_b \times B_b^{high} + \gamma_{1t}y_{bt-n} + \gamma_{2t}L_b \times y_{bt-n} + BORD_b + \boldsymbol{X}_b'\delta + C_t + PLU_t + \varepsilon_{bt} \quad (3.1)$$

In Sect. 3.3.1, I also estimate Eq. (3.1) replacing average annual Loan Fund lending during the famine with a binary variable for Loan Fund presence during the famine. Since farm size data before 1845 and crop data from 1847 to 1851 and after 1871 are not available at the baronial level, I again estimate changes at the PLU level. Modifying Eq. (3.1), each outcome, Y_{ut}, in PLU u and year t is differenced from its pre-famine value, Y_{upre}, and the difference regressed on blight severity ($B_b^{med\text{-}high}$), a binary variable for Loan Fund presence during any one of the preceding famine years (L_u), the fraction of total PLU border length shared with other PLUs with at least one Loan Fund during the famine ($BORD_u$), pre-famine PLU characteristics ($\boldsymbol{X}_u$), a categorical variable for county (C_t), and an error term (ε_{ut}). Additionally, Loan Fund presence is interacted with blight severity and with lags of PLU outcomes (y_{ut-n}):

$$Y_{ut} - Y_{upre} = \beta_{1t}B_u^{med-high} + \beta_{2t}L_u + \beta_{3t}L_u \times B_u^{med-high} + \gamma_{1t}y_{ut-n} + \gamma_{2t}L_u \times y_{ut-n} + BORD_u + \boldsymbol{X}_u'\delta + C_t + \varepsilon_{ut} \quad (3.2)$$

[6] The lags of baronial outcomes are for available pre-famine survey years excluding the immediately preceding survey year, Y_{bpre}.

[7] For two time periods, first-difference and fixed-effects estimators are numerically equivalent. As with fixed effects, differencing eliminates time-invariant baronial characteristics and thereby yields consistent and unbiased estimators. Differencing is more efficient when the untransformed error term more closely follows a random walk. Clustering corrects for any possible serial correlation in the errors.

Finally, as a falsification exercise, in Sect. 3.3.2, I estimate Eqs. (3.1) and (3.2) using the number of banks in 1843 in lieu of Loan Fund presence or lending.

Differencing allows us to control for unobservable baronial or PLU characteristics that vary across baronies but are fixed over time, while county and PLU categorical variables allow us to control for unobservable variables that vary by year but are constant across administrative units. For non-fixed but observable baronial characteristics, the included controls in Eqs. (3.1) and (3.2) are area, 1841 population, baronial valuations completed by 1845, adult literacy rate (reading, writing, or both) in 1841, the potato crop share of total tillage acreage in 1844, and the fraction of housing rated fourth class in the 1841 census. In the absence of income or wealth statistics, these variables are included as proxies for development and poverty. Acreage under potato crop as a share of total tillage acreage in 1844 is also included to allow baronies similarly impacted by blight but with different pre-famine levels of potato dependence to experience systematically different changes after 1845. Each regression furthermore includes the relevant outcome variable in the most proximate pre-famine year and all available pre-famine periods to control for possible pre-trends. Loan Fund lending is interacted with lagged outcomes to allow for the possibility that Loan Fund activity may have had more or less of an effect where there were already more people and/or tillage acres under potato crop.[8] Including the fraction of total baronial or PLU border length shared with other baronies or PLUs with at least one Loan Fund during the famine allows us to control for possible spatial autocorrelation or border effects.

Along these observable dimensions, in Eqs. (3.1) and (3.2), baronies and PLUs with or without a Loan Fund, or with different levels of Loan Fund lending during the famine, are allowed to experience systematically different relative changes after 1845, with the identification assumption that districts with or without a Loan Fund, or with more

[8] Data limitations do not permit us to include pre-famine observations of farm size and livestock holdings.

or less Loan Fund lending during the famine, but in the same region and with similar pre-famine characteristics and levels of blight infection would otherwise have followed similar trajectories in population change and adjustment in land use if not for differential access to Loan Fund credit.

The coefficients β_{4t} and β_{5t} in Eq. (3.1) and β_{3t} in Eq. (3.2) report whether baronies and PLUs suffering from medium-, high-, or medium-high-blight infection, respectively, in 1845 and 1846 changed differently than baronies and PLUs with low- or low-medium-blight infection when there was a Loan Fund, or more Loan Fund lending, compared to the difference in changes between medium-, high-, or medium-high-infection and low- or low-medium-infection baronies or PLUs when there was no Loan Fund or less lending. In this way, the coefficients β_{4t} and β_{5t} in Eq. (3.1) and β_{3t} in Eq. (3.2) compare average changes in worse infected baronies or PLUs with a Loan Fund relative to less infected baronies or PLUs with a Loan Fund, versus average changes in worse infected baronies or PLUs without a Loan Fund relative to less infected baronies or PLUs without a Loan Fund.

Because it is a strong identifying assumption that the establishment of a Loan Fund was uncorrelated with other, unobservable, non-fixed baronial characteristics that might have been correlated with differential responses to blight, in Sect. 3.3.3, I estimate Eqs. (3.1) and (3.2) by two-stage least squares (2SLS) regression, using the presence of an Association of Irish Musical Societies (AIMS) musical society in a given barony or PLU to instrument for the presence of a Loan Fund during the famine. Because Eqs. (3.1) and (3.2) include numerous interactions with Loan Fund presence as explanatory variables, instruments are AIMS musical society presence (M_b), as well as interactions of AIMS musical society presence with blight ($M_b \times B_b^{med}$ and $M_b \times B_b^{high}$), and lags of pre-famine outcomes ($M_b \times y_{bt-n}$). The first stage therefore consists of separately regressing each endogenous regressor (L_b, $L_b \times B_b^{med}$, $L_b \times B_b^{high}$, $L_b \times y_{bt-n}$, and $BORD_b$) on all instruments (M_b, $M_b \times B_b^{med}$, $M_b \times B_b^{high}$, $M_b \times y_{bt-n}$, and $BORD_M_b$) and all exogenous regressors to generate fitted values.

Several additional estimation details are worth noting. First, regressions for livestock outcomes are subdivided by farm size to allow for average effects to differ for different types of farms or farms of different scale.[9] Second, the outcome years analyzed are selected so as to, where possible, estimate average effects 1, 5, 10, 20, and 40 years after the end of the famine in 1851. Where it is possible to analyze outcomes between 1845 and 1851—in other words, during the famine years—I do so. Third, standard errors are clustered at the baronial level (PLU level for estimations of Eq. (3.2)) to adjust for heteroskedasticity and within-barony or within-PLU correlation over time. Fourth, to test whether observed effects were the result of microfinance lending by the Irish Loan Funds in particular or financial services more broadly, I re-estimate Eqs. (3.1) and (3.2) in Sect. 3.3.2 by replacing Loan Fund variables and interactions with the number of banks.

3.3 Results

Results from estimating Eqs. (3.1) and (3.2) are presented in Fig. 3.1. Panels A through D graph estimated coefficients (β_{4t}'s, β_{5t}'s, and β_{3t}'s) from Eqs. (3.1) and (3.2), representing differences in relative changes in the indicated outcome variable in medium- or high-impact baronies or medium-high-impact PLUs relative to low-impact baronies or low-medium-impact PLUs where there was at least one Loan Fund during the famine years versus not. Panels E and F graph estimated coefficients representing differences in relative changes in pig and poultry holdings in high-impact baronies relative to low-impact baronies where there was at least one active Loan Fund during the famine years versus not, subdivided by farm size. To test whether observed effects were the result of microfinance lending by the Loan Funds in particular or financial services more broadly, I re-estimate Eqs. (3.1) and (3.2) in Sect. 3.3.2 by replacing Loan Fund variables and interactions with the number of banks in 1843. Results are analyzed in Sects. 3.3.1, 3.3.2, and 3.3.3.

[9] Available data do not allow us to distinguish average changes in population and crop acreage by farm size.

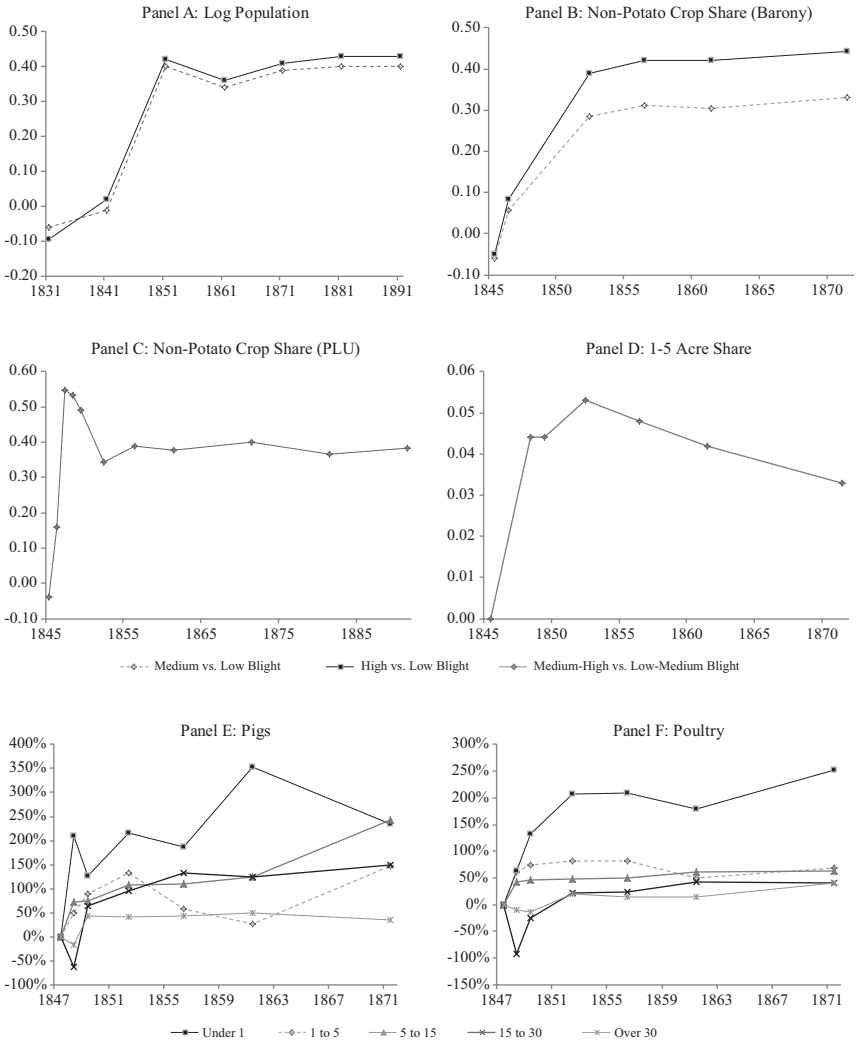

Fig. 3.1 Estimated changes by blight severity and Loan Fund presence (Notes: Panels A through D graph estimated coefficients ($\beta_{4,5t}$'s and β_{3t}'s) from Eqs. (3.1) and (3.2) in the text, representing differences in changes in the indicated outcome variable in high- or medium-impact baronies or medium-high-impact PLUs relative to low-impact baronies or low-medium-impact PLUs where there was at least one active Loan Fund during the famine years versus where there was not. For illustrative purposes, in Panels B and C, I reverse the sign on the estimated coefficients so as to present estimated relative changes in the fraction of total tillage acreage not under potato crop. Panels E and F graph estimated coefficients representing differences in changes in pig and poultry holdings in high-impact baronies relative to low-impact baronies where there was at least one active Loan Fund during the famine years versus where there was not, subdivided by farm size)

3.3.1 Loan Funds

Results presented in Tables 3.1, 3.2, 3.3 and 3.4 reveal that Loan Funds were strongly correlated with non-demographic adjustment to blight, in particular through greater crop diversification, short-run accumulation of buffer livestock holdings, and medium- to long-run substitutions toward pasture.

Estimated coefficients reported in Tables 3.1 and 3.2 indicate that Loan Funds had highly significant effects on changes in poultry and pig holdings—traditional buffers against crop failure owing to their minimal acreage requirements, easy liquidation, and abilities to forage—during and immediately after the famine years for small- to medium-sized farms, especially those between 1 and 15 acres. Columns 3 and 4 of Table 3.1 show that one year on from "Black '47," relative to farms of 1 to 5 acres in moderately infected baronies, farms of 1 to 5 acres in severely and considerably infected baronies with a Loan Fund had increased poultry stocks by 61.1 and 50.3 percentage points more, respectively, than farms of 1 to 5 acres in severely and considerably infected baronies without a fund. Columns 5 and 6 report corresponding differential relative changes of 41.7 and 39.7 percentage points, respectively, for farms of 5 to 15 acres in severely and considerably infected baronies. Relative accumulations of poultry, however, again appear to have been exclusively short- to medium-run responses to blight, with observed differential relative changes dissipating entirely for farms of 5 to 15 acres by 1852 and after 1856 for farms of 1 to 5 acres.[10]

[10] To put these figures in perspective, estimated coefficients in Table 3.1 imply that in 1848, relative to farms of up to 15 acres in moderately infected baronies, farms of up to 15 acres in severely infected baronies with a Loan Fund relatively increased total poultry stocks by 214,732 more chickens than farms of up to 15 acres in severely infected baronies without, or approximately 2 more chickens per 1848 farm. Even assuming an inflated price of 2 shillings per chicken, this corresponds to a total purchase cost of £21,473. Estimated coefficients in Table 3.2 imply that in 1848, farms of 5 to 15 acres in severely infected baronies with a Loan Fund also relatively increased pig stocks by 15,350 more pigs (0.25 per 1848 farm) than farms of 5 to 15 acres in severely infected baronies without, which even at a much inflated price of £2 per pig would correspond to a total purchase cost of £30,700. In the preceding year, funds in severely infected baronies extended 92,996 loans, totaling £326,204, which means that even using inflated cost estimates, relative increases in chicken and pig holdings would only have consumed at most just 16% of Loan Fund lending. 214,732 chickens laying between 100 and 150 eggs a year each would then have generated sufficient income, after interest and cost of feed, to purchase enough meal to sustain between 7,500

Table 3.1 Estimated changes in poultry holdings by Loan Fund presence

	Under 1 acre		*1–5 acres*		*5–15 acres*		*15–30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	0.631*	0.567**	0.611***	0.503***	0.417***	0.397***	−0.920	−1.010	−0.101	−0.050
	(0.34)	(0.28)	(0.15)	(0.10)	(0.13)	(0.13)	(1.04)	(1.39)	(0.18)	(0.18)
1849	1.314*	0.576	0.746***	0.678***	0.457**	0.420**	−0.251	0.112	−0.130	0.117
	(0.77)	(0.72)	(0.19)	(0.14)	(0.22)	(0.19)	(0.16)	(0.12)	(0.15)	(0.09)
1852	2.075	1.965	0.823***	0.703***	0.483	0.593	0.221	0.450	0.202	0.252
	(2.71)	(2.34)	(0.21)	(0.21)	(0.35)	(0.37)	(0.39)	(0.40)	(0.16)	(0.17)
1856	2.091	1.367	0.821***	0.617***	0.497	0.593	0.236	0.450	0.144	0.252
	(1.75)	(1.45)	(0.21)	(0.23)	(0.38)	(0.37)	(0.34)	(0.40)	(0.15)	(0.17)
1861	1.796	1.254	0.497	0.393	0.605	0.810	0.434	0.628	0.151	0.033
	(1.63)	(1.54)	(0.81)	(0.69)	(0.45)	(0.51)	(0.45)	(0.54)	(0.17)	(0.16)
1871	2.514	1.445	0.686	0.644	0.631	0.909	0.402	0.386	0.403*	0.159
	(4.14)	(4.09)	(0.75)	(0.77)	(0.63)	(0.79)	(0.45)	(0.46)	(0.20)	(0.17)
N	202		202		202		202		202	
R2	0.216		0.388		0.381		0.626		0.595	

Notes: Each column reports estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) in the text) for changes in the number of poultry, subdivided by farm size, in the indicated year by blight severity interacted with Loan Fund presence during the famine. All regressions control for area, partial adult literacy in 1841, 1841 population, pre-famine baronial valuation, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 3.2 Estimated changes in swine holdings by Loan Fund presence

	Under 1 acre		*1–5 acres*		*5–15 acres*		*15–30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	2.086	1.020*	0.490	0.303	0.724***	0.516***	−0.626	−0.833	−0.176	−0.228
	(1.42)	(0.59)	(0.40)	(0.39)	(0.18)	(0.13)	(0.89)	(1.20)	(0.40)	(0.39)
1849	1.273**	0.59	0.888**	0.522	0.750**	0.564	0.631	0.590	0.423	0.290
	(0.53)	(0.54)	(0.42)	(0.42)	(0.37)	(0.36)	(0.48)	(0.51)	(0.32)	(0.32)
1852	2.166**	1.714	1.333***	0.937*	1.069*	0.839	0.946	1.287	0.406	0.468
	(0.99)	(1.04)	(0.44)	(0.50)	(0.64)	(0.67)	(0.88)	(1.07)	(0.46)	(0.57)
1856	1.873	0.773	0.584*	0.269	1.093**	0.973*	1.330*	1.610	0.441	0.463
	(1.49)	(1.08)	(0.33)	(0.38)	(0.44)	(0.50)	(0.73)	(0.99)	(0.41)	(0.53)
1861	3.528*	0.984	0.271	0.031	1.234	1.678*	1.237	2.494	0.488	0.875
	(1.91)	(1.05)	(1.20)	(1.16)	(0.87)	(0.97)	(1.63)	(2.21)	(0.59)	(0.84)
1871	2.349	1.494	1.463	1.899	2.422	3.287	1.490	2.009	0.357	0.653
	(2.06)	(1.68)	(2.58)	(2.69)	(1.81)	(2.40)	(1.72)	(1.88)	(0.70)	(0.83)
N	202		202		202		202		202	
R2	0.285		0.264		0.384		0.634		0.614	

Notes: Each column reports estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) in the text) for changes in the number of swine, subdivided by farm size, in the indicated year by blight severity interacted with Loan Fund presence during the famine. All regressions control for area, partial adult literacy in 1841, 1841 population, pre-famine baronial valuation, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Though estimated coefficients reported in columns 1 and 2 of Table 3.1 indicate that, relative to farms under 1 acre in moderately infected baronies, farms under 1 acre in severely and considerably infected baronies with a Loan Fund increased poultry stocks by 63.1 and 56.7 percentage points more in 1848 than farms under 1 acre in severely and considerably infected baronies without a fund, the results are statistically significant only at the levels of $\alpha = 0.10$ and 0.05, and dissipate from 1849. Results reported in columns 1 and 2 of Table 3.1 therefore suggest that microloans for the acquisition of poultry stocks generally may not have been reaching the very poorest Irish farmers.

Estimated coefficients reported in columns 1 through 6 of Table 3.2 show that Loan Funds were also associated with greater short- to medium-run accumulations of pig stocks, though exclusively for farms of 15 acres or less and predominantly in severely infected districts. By 1852, relative to farms of under 1 acre, 1 to 5 acres, and 5 to 15 acres in moderately infected baronies, farms of under 1 acre, 1 to 5 acres, and 5 to 15 acres in severely infected baronies with a Loan Fund had increased pig stocks by 216.6, 133.3, and 106.9 percentage points more, respectively, than farms of corresponding size in severely infected baronies without a fund. Observed differential relative changes in pig holdings, however, appear to have largely dissipated by 1861, which again suggests that pig stocks did not constitute a major long- to very long-run margin of adjustment. Estimated coefficients also further reveal that the strongest effects of Loan Fund activity on the accumulation of buffer pig stocks were concentrated among small- to medium-sized farms, with estimated effects on the very smallest farms being both statistically weaker and smaller in absolute terms.[11]

While Loan Funds do not appear to have been associated with short-run accumulations of grazing stock, estimated coefficients reported in columns

and 12,000 adult men for one year, while 15,350 pigs would have generated sufficient income, after interest and feed, to purchase enough meal to sustain 1,300 adult men for one year.

[11] Though estimated coefficients in columns 1 and 2 of Table 3.2 indicate that the effect of Loan Fund presence in severely infected baronies on relative pig accumulations may have been large in percentage terms, in terms of actual numbers of stock, the relative increase in pig holdings by farms of 1–5 and 5–15 acres in severely infected baronies with a fund was roughly four times that by farms under 1 acre in those baronies.

5 and 6 of Table 3.3 indicate they were associated with greater medium- and long-run substitutions away from potato cultivation toward pasture, though only by farms of 5–15 acres. Five years on from the worst year of the famine, relative to farms of 5–15 acres in moderately infected baronies, farms of 5–15 acres in severely and considerably infected baronies with a Loan Fund had increased cattle stocks by 31.1 and 28.5 percentage points more, respectively, than farms of corresponding size in severely and considerably infected baronies without a fund. By 1861, relative to 5- to 15-acre farms in moderately infected baronies, cattle stocks held by farms of 5–15 acres in severely and considerably infected baronies with a Loan Fund had increased by 35.1 and 29.8 percentage points more, respectively, than cattle stocks held by 5- to 15-acre farms in severely and considerably infected baronies without a fund. Loan Funds do not, however, appear to have been associated with any differential relative changes in aggregate holdings of horses, mules, asses, goats, or sheep (not displayed) by farms of any size.

Loan Fund lending was strongly associated with larger and more rapid crop portfolio diversification. Estimated coefficients reported in Panel A, columns 3 and 4 of Table 3.4, show that after the first year of blight, baronies with an active Loan Fund during the preceding year suffering severe or considerable blight infection in 1845–46 experienced relative increases in the non-potato crop share of total tillage acreage that were 8.3 and 5.6 percentage points greater, respectively, than in severely and considerably infected baronies without a Loan Fund. By the end of the famine, relative increases in the non-potato crop share were 39.0 and 28.4 percentage points greater in severely and considerably infected baronies with a Loan Fund versus those without, with the estimated relative differential persisting at a roughly constant level through 1871. Estimated coefficients reported in Panel B, columns 3 and 4 of Table 3.4, reveal that at the intensive margin, severely and considerably affected baronies with 10% more in average annual Loan Fund lending from 1845 to 1850 increased acreage allocated to other crops by 0.34 and 0.27 percentage points more, respectively, by the end of the famine than severely and considerably affected baronies without.

As noted in Sect. 3.2, for the years 1847–49, 1881, and 1891, I also estimate Eq. (3.2) changes at the PLU level. Estimates reported in Panel A, column 5 of Table 3.4, indicate that Loan Fund activity

had a very large effect on crop acreage reallocation during the famine years, particularly following two successive crop failures. After a 15.9-percentage point larger relative decline in the potato crop's share of total acreage under tillage crop in 1846, in 1847, medium-high-impact PLUs with a Loan Fund had, relative to low-medium-impact PLUs, reduced the potato's share of total crop acreage by an estimated 54.6 percentage points more than medium-high-impact PLUs without a fund. Estimated coefficients then indicate a slight relative reallocation to the potato in 1848 and 1849, with the difference in the relative decline in potato crop share in medium-high-impact PLUs with a Loan Fund versus those without dropping to 34.3 percentage points by 1852.

Estimated coefficients in Panel A, columns 1 and 2 of Table 3.4, show that the relative population decline between 1841 and 1851, compared to moderately infected baronies, was 42.1% and 40.3% smaller in severely and considerably infected baronies with a Loan Fund versus severely and considerably infected baronies without.[12] These smaller relative population declines, moreover, were highly persistent, with the cumulative population decline in severely and considerably infected baronies with a Loan Fund versus severely and considerably infected baronies without, relative to moderately infected baronies, still 43.3% and 40.8% smaller, respectively, in 1891. Loan Funds were also associated with smaller relative population declines at the intensive margin. Estimated coefficients reported in Panel B, columns 1 and 2 of Table 3.4, show that severely and considerably affected baronies with 10% more in average annual Loan Fund lending from 1845 to 1850 experienced relative population declines that were persistently 0.52% and 0.49% smaller than severely and considerably affected baronies without.

Results presented in column 7 of Table 3.4 indicate that Loan Funds were also associated with smaller relative declines in the share of all farmholdings measuring between 1 and 5 acres. By 1848, relative to

[12] While loans were not extended to finance emigration, they were occasionally extended to finance seasonal or otherwise temporary migration across the Irish Sea for industrial employment in Scotland and England, with borrowers remitting earnings to family back in Ireland during their spell abroad. Steerage passage from Ireland to England or Scotland was typically a few shillings. See Ó Gráda and O'Rourke (1997).

Table 3.3 Estimated changes in cattle holdings by Loan Fund presence

	Under 1 acre		*1–5 acres*		*5–15 acres*		*15–30 acres*		*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1848	0.424	0.084	0.063	0.160**	0.128	0.103	−2.266	−2.059	0.006	−0.016
	(0.43)	(0.59)	(0.12)	(0.07)	(0.18)	(0.18)	(2.25)	(1.67)	(0.12)	(0.09)
1849	0.524	0.655	0.195	0.224	−0.046	−0.012	−0.174	−0.159	0.140	0.118
	(0.49)	(0.45)	(0.13)	(0.14)	(0.21)	(0.22)	(0.25)	(0.25)	(0.09)	(0.10)
1852	1.041	0.811	0.239	0.218	0.311*	0.285*	−0.202	−0.222	−0.055	−0.077
	(0.74)	(0.61)	(0.22)	(0.21)	(0.17)	(0.16)	(0.41)	(0.40)	(0.29)	(0.29)
1856	0.078	0.101	0.249	0.219	0.415**	0.361**	0.077	−0.008	0.075	0.024
	(0.15)	(0.18)	(0.18)	(0.16)	(0.18)	(0.17)	(0.37)	(0.36)	(0.34)	(0.33)
1861	0.068	0.037	0.203	0.150	0.351***	0.298***	−0.244	−0.323	0.121	0.073
	(0.21)	(0.24)	(0.19)	(0.18)	(0.12)	(0.10)	(0.53)	(0.51)	(0.30)	(0.29)
1871	0.155	−0.017	−0.002	−0.092	0.476	0.337*	−0.934	−0.903	0.051	−0.033
	(0.25)	(0.34)	(0.26)	(0.22)	(0.29)	(0.18)	(0.81)	(0.79)	(0.32)	(0.31)
N	202		202		202		202		202	
R2	0.602		0.509		0.576		0.629		0.566	

Notes: Each column reports estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) in the text) for changes in the number of cattle, subdivided by farm size, in the indicated year by blight severity interacted with Loan Fund presence during the famine. All regressions control for area, partial adult literacy in 1841, 1841 population, pre-famine baronial valuation, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 3.4 Estimated changes in population, potato crop share, and farm size by Loan Fund activity

	Population		Potato crop share			Farm size	
						<1 acre	*1–5 acre*
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Med–high vs. low–med	Med–high vs. low–med	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Loan Fund							
1846			−0.083***	−0.056***	−0.159***		
			(0.02)	(0.02)	(0.00)		
1847					−0.546**		
					(0.22)		
1848					−0.532**	−0.034	0.044*
					(0.21)	(0.07)	(0.02)
1849					−0.490**	−0.022	0.044**
					(0.23)	(0.06)	(0.02)
1851	0.421***	0.403***					
	(0.13)	(0.14)					
1852			−0.390***	−0.284***	−0.343*	−0.018	0.053**
			(0.08)	(0.06)	(0.18)	(0.04)	(0.02)
1856			−0.422***	−0.312***	−0.388*	−0.019	0.048***
			(0.07)	(0.06)	(0.20)	(0.04)	(0.02)
1861	0.369**	0.344**	−0.421***	−0.304***		−0.014	0.042**
	(0.15)	(0.15)	(0.08)	(0.06)		(0.04)	(0.02)
1871	0.416***	0.391***	−0.443***	−0.330***		−0.001	0.033*
	(0.15)	(0.15)	(0.08)	(0.07)		(0.04)	(0.02)
1891	0.433***	0.408***			−0.382*		
	(0.15)	(0.16)			(0.20)		

B. Log annual lending

1846			−0.005***	−0.006***			
			(0.00)	(0.00)			
1851	0.052***	0.049***					
	(0.02)	(0.02)					
1852			−0.034***	−0.027***			
			(0.01)	(0.01)			
1856			−0.040***	−0.032***			
			(0.01)	(0.01)			
1861	0.050***	0.046***	−0.041***	−0.032***			
	(0.02)	(0.02)	(0.01)	(0.01)			
1871	0.056***	0.052***	−0.042***	−0.033***			
	(0.02)	(0.02)	(0.01)	(0.01)			
1891	0.061***	0.057***					
	(0.02)	(0.02)					
N	188		206		93	93	93
R2	0.691		0.786		0.377	0.461	0.581

Notes: Each column reports estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) and β_{3t}'s from Eq. (3.2) in the text) for changes in log population, the fraction of total tillage acres under potato crop, and the fraction of all farmholdings measuring under 1 acre and between 1 and 5 acres in the indicated year by blight severity and Loan Fund presence during the famine (Panel A) and log of average annual Loan Fund lending between 1845 and 1850 (Panel B). All baronial-level regressions control for area, partial adult literacy in 1841, pre-famine baronial valuation, total population in 1841, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. All PLU-level regressions control for area, pre-famine valuation, 1841 population, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total PLU border length shared with other PLUs with at least one Loan Fund during the famine, and county. Robust standard errors are reported in parentheses and clustered at the baronial or PLU level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

low-medium-blight PLUs, the decrease in the 1–5-acre share of all farmholdings was 4.4 percentage points larger in medium-high-blight PLUs *without* a Loan Fund versus those with a Loan Fund. By the end of the famine, the relative decrease in the fraction of all farms measuring between 1 and 5 acres was 5.3 percentage points greater in medium-high-blight PLUs without a Loan Fund versus those with a fund. In contrast, the signs on estimated coefficients reported in column 6 for relative changes in the share of all farmholdings measuring under 1 acre are in fact negative, though none are statistically significant. Results reported in columns 6 and 7 thus again suggest that Loan Fund lending had the largest effects on small- to medium-sized farms, rather than on the very smallest farms.

3.3.2 Banks

As a falsification exercise to explore whether observed differences in relative changes were the result of Loan Fund microlending in particular or the presence of financial services, and potential unobservable correlates, more generally, I re-estimate Eqs. (3.1) and (3.2) using the number of banks in 1843. Estimated coefficients reported in columns 1 and 2 of Table 3.5 show that the presence of an additional bank appears to have had no effect on differential demographic outcomes of blight. Severely and considerably impacted baronies with an additional bank experienced no statistically significant differences in relative population decline versus those without. Estimated coefficients reported in columns 3 through 5 of Table 3.5 likewise reveal that the presence of an additional bank had no statistically significant effect on differential relative changes in tillage acreage allocated to potato crop in worse infected baronies and PLUs versus those without. Banks may have had a short-run effect on relative changes in average farm size, with estimated coefficients reported in column 7 of Table 3.5 showing that by 1848, the relative decline in the share of all farmholdings between 1 and 5 acres was 11.9 percentage points larger in medium-high-impact PLUs with one more bank, versus those without.[13] But by 1852, the estimated effect dissipates entirely,

[13] Unfortunately, in the absence of additional historical and statistical evidence, it is not possible to determine the mechanism by which banks may have effected a short-run relative decline in the

Table 3.5 Estimated changes in population, potato crop share, farm size, and cattle holdings by a number of banks

	Population		Potato crop share			Farm size		Cattle	
						< 1 acre	*1–5 acres*	*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Med-high vs. low-med	Med-high vs. low-med		High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1846			−0.003	−0.005	0.008				
			(0.00)	(0.00)	(0.02)				
1847					−0.011				
					(0.01)				
1848					−0.014	−0.070	−0.119**	0.037	0.061
					(0.02)	−0.070	−0.050	(0.03)	(0.04)
1849					−0.015	−0.055	−0.118**	0.084*	0.148***
					(0.02)	−0.070	−0.050	(0.05)	(0.05)
1851	0.158	0.154							
	(0.13)	(0.13)							
1852			−0.013	−0.012	−.008	−0.032	−0.008	−0.011	0.221**
			(0.01)	(0.01)	(0.05)	(0.06)	(0.04)	(0.08)	(0.11)
1856			−0.013	−0.009	−0.003			−0.194*	0.184*
			(0.01)	(0.01)	(0.01)			(0.11)	(0.10)
1861	0.139	0.129	−0.014	−0.010		−0.022	0.006	−0.309**	0.120
	(0.13)	(0.13)	(0.01)	(0.01)		−0.060	−0.030	(0.13)	(0.08)
1871	0.124	0.114	−0.016	−0.009		0.003	−0.001	−0.435**	0.100
	(0.13)	(0.13)	(0.01)	(0.01)		−0.060	−0.040	(0.18)	(0.11)
1891	0.163	0.155			−0.01				
	(0.12)	(0.13)			(0.02)				

(*continued*)

Table 3.5 (continued)

	Population		Potato crop share			Farm size		Cattle	
						< 1 acre	*1–5 acres*	*Over 30 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Med-high vs. low-med	Med-high vs. low-med		High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
N	188		206		93	93	93	202	
R2	0.627		0.756		0.307	0.259	0.242	0.357	

Notes: Each column reports estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) and β_{3t}'s from Eq. (3.2) in the text) for changes in log population, the fraction of total tillage acres under potato crop, the fraction of all farmholdings measuring under 1 acre and between 1 and 5 acres, and cattle holdings by farms over 30 acres in the indicated year by blight severity and the number of banks in 1843. Baronial-level regressions control for available pre-famine observations of outcome variables, area, partial adult literacy in 1841, pre-famine baronial valuation, the share of housing rated fourth class, and PLU and county. PLU-level regressions control for available pre-famine outcome variable observations, area, pre-famine valuation, and county. Robust standard errors are reported in parentheses and clustered at the baronial or PLU level. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$

suggesting that banks had no long-run impact on relative changes in farm size dispersion in areas worse affected by blight.

Banks also appear to have had little or no effect on relative changes in livestock holdings in baronies worse affected by blight. There were no statistically significant differences, over any time horizon, in relative changes in holdings of poultry, pigs, sheep, goats, horses, mules, or asses (not displayed) for farms of any size in severely and considerably impacted baronies with one more bank versus those without. Estimated coefficients reported in columns 8 and 9 of Table 3.5 do suggest that the presence of an additional bank in severely and considerably impacted baronies may have had an effect on relative changes in holdings of cattle by farms larger than 30 acres, but the sign of the effect is ambiguous, with banks appearing to have had opposite relative effects in considerably versus severely impacted baronies. These estimates, moreover, are only statistically significant at the 10% level and are small in absolute terms.

3.3.3 Two-Stage Least Squares Analysis

Because it is a strong identifying assumption that the establishment of a Loan Fund was uncorrelated with other, unobservable, non-fixed baronial characteristics that might have been correlated with differential responses to blight, I re-estimate Eqs. (3.1) and (3.2) by two-stage least squares regression, using the presence of an Association of Irish Musical Societies (AIMS) musical society in a given barony or PLU as an instrument for the presence of a Loan Fund during the famine. In the 1740s and 1750s, the Dublin Musical Society began extending small loans to poor Dubliners and in 1756 incorporated a formal society for this purpose. Thereafter, the Dublin Musical Society for a brief time operated a loosely affiliated branch system of musical loan societies, "To receive contributions, and to lend out such sum or sums of money interest free" to poor farmers and laborers. These constituted many of the first Loan Funds, though over time numerous pawnbrokers and Mont-de-Piétés reconstituted as Loan Funds, with all such societies eventually being formally unified and

fraction of all farmholdings between 1 and 5 acres in worse affected PLUs. It is conceivable that banks and bank loans were associated with consolidation of smaller plots, or the presence of an additional bank may simply have been correlated with unobservable, non-fixed PLU characteristics that were negatively correlated with changes in the 1–5-acre share of farmholdings.

lending practices standardized under the central Loan Fund Board in the 1830s (Hollis and Sweetman 1998, 2001; McLaughlin 2009).[14]

The inclusion and exclusion restrictions are that the presence of an AIMS musical society in a given barony or PLU is correlated with the presence of a Loan Fund in the same barony or PLU during the famine, but is otherwise uncorrelated with ε_{bt} or ε_{ut}. Since AIMS musical societies are generally small troupes that often travel frequently for performances, it is unlikely that their presence is correlated with other unobservable variables that might have differentially affected relative adjustment to blight, for example, wealth and social capital. Nonetheless, as a robustness check, I regress AIMS musical society presence on pre-famine baronial characteristics, with results presented in Table 1.3. OLS-estimated coefficients presented in column 5 indicate that pre-famine baronial characteristics are poor predictors of AIMS presence. None of the estimated coefficients are statistically significant, and the fit is poor. In particular, that estimated coefficients on baronial valuation, potato crop, and fourth-class housing shares are not significant suggests that musical societies were not correlated with pre-famine levels of poverty. The fact that estimated coefficients on literacy, population density, and especially religious diversity are also not significant indicates that local differences in social capital were likewise uncorrelated with AIMS presence.

The results of estimating Eqs. (3.1) and (3.2) for average changes in population levels, potato crop share, and small farms (<5 acres) as a share of total farmholdings by 2SLS, with the coefficients on Loan Fund presence exactly identified, are presented in Table 3.6.[15] The results of estimating Eq. (3.1) for average changes in the value of buffer (swine and poultry) and grazing (cattle, sheep, and goats) livestock for farms of <15 acres and >15 acres by 2SLS, with the coefficients on Loan Fund presence exactly identified, are presented in Table 3.8. First-stage estimates of Loan Fund presence or average annual lending and Loan

[14] As data is not available on musical societies by barony in the eighteenth and nineteenth centuries, I instead use current AIMS member societies as an instrument.

[15] For economy of presentation, I report only short- and medium-run estimates, since the analysis in this chapter is particularly concerned with the role of microfinance in facilitating short- and medium-run non-demographic adjustment.

Table 3.6 2SLS-estimated changes in population, potato crop share, and farm size by blight severity interacted with Loan Fund presence or average annual lending

	Population (levels)		Potato crop share			<5 Acres farm share
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Med-high vs. low-med (PLU)	Med-high vs. low-med (PLU)
	(1)	(2)	(3)	(4)	(5)	(6)
A. Loan Fund presence						
1846			−0.066**	−0.062*	−0.114**	
			(0.03)	(0.03)	(0.05)	
1847					−0.394*	
					(0.20)	
1848					−0.377*	0.070
					(0.22)	(0.07)
1849						0.055
						(0.07)
1851	3660.500*	3460.445*				
	(2043.75)	(2078.59)				
1852			−0.293***	−0.282**	−0.346*	0.114*
			(0.11)	(0.11)	(0.18)	(0.06)
1856			−0.332***	−0.321***	−0.328*	0.100*
			(0.12)	(0.12)	(0.18)	(0.06)
B. Average annual lending						
1846			0.001**	0.000		
			(0.00)	(0.00)		
1851	1.659**	1.245*				
	(0.69)	(0.72)				
1852			0.008***	0.006**		
			(0.00)	(0.00)		
1856			0.009***	0.006***		
			(0.00)	(0.00)		
N	188		206		93	93
R2	0.660 (A) 0.593 (B)		0.532 (A) 0.420 (B)		0.230	0.163

Notes: Each column reports 2SLS-estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) and β_{3t}'s from Eq. (3.2) in the text) for changes in the indicated outcome

(*continued*)

Table 3.6 (continued)

variable in the indicated year by blight severity interacted with Loan Fund presence during the famine (Panel A) or with average annual Loan Fund lending from 1845 through 1850 (Panel B), with Loan Fund presence and average annual lending during the famine instrumented by AIMS musical society presence. Loan Fund presence (Panel A) or average annual lending (Panel B) during the famine is also fully interacted with available pre-famine lags of the indicated outcome variable. All baronial-level regressions control for area, partial adult literacy in 1841, pre-famine baronial valuation, total population in 1841, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. All PLU-level regressions control for area, pre-famine valuation, 1841 population, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total PLU border length shared with other PLUs with at least one Loan Fund during the famine, and county. Robust standard errors are reported in parentheses and clustered at the baronial or PLU level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Fund presence or average annual lending interacted with blight severity, instrumented for by AIMS musical society presence and AIMS musical society presence interacted with blight severity, are reported in Table 3.10. Results reported in Tables 3.6 and 3.8 show that the estimated effects of Loan Fund presence remain significant and robust to estimation by 2SLS.

2SLS-estimated coefficients in Panel A, columns 1 and 2 of Table 3.6, show that the population decline between 1841 and 1851, relative to low-blight baronies, was smaller by 3660.500 and 3460.445 persons in high- and medium-blight baronies with a Loan Fund versus high- and medium-blight baronies without. Loan Funds were also associated with smaller relative population declines at the intensive margin. Estimated coefficients reported in Panel B, columns 1 and 2 of Table 3.6, show that, relative to low-blight baronies, high- and medium-blight baronies with £1 more in average annual Loan Fund

lending from 1845 to 1850 experienced relative population declines that were smaller by 1.659 and 1.245 persons by 1851 than high- and medium-blight baronies without. Results presented in column 6 of Table 3.6 indicate that Loan Funds were also associated with smaller relative declines in the share of all farmholdings measuring under 5 acres. By 1852, relative to low-medium-blight PLUs, the decline in the under-5-acre share of all farmholdings was 11.4 percentage points larger in medium-high-blight PLUs without a Loan Fund versus those with a Loan Fund.

Loan Fund lending is again strongly associated with larger and more rapid relative crop portfolio diversification. 2SLS-estimated coefficients reported in Panel A, columns 3 and 4 of Table 3.6, show that after the first year of blight, high- and medium-blight baronies with an active Loan Fund during the preceding year experienced relative increases in the non-potato crop share of total tillage acreage that were 6.6 and 6.2 percentage points greater, respectively, than in severely or considerably infected baronies without a Loan Fund. By the end of the famine, relative increases in the non-potato crop share were 29.3 and 28.2 percentage points greater in severely and considerably infected baronies with a Loan Fund versus those without. 2SLS-estimated coefficients reported in Panel B, column 3 of Table 3.6, likewise reveal that at the intensive margin, relative to low-blight baronies, high-blight baronies with £1000 more in Loan Fund lending in 1845 increased acreage allocated to other crops in 1846 by 1-percentage point more than high-blight baronies without. Estimated coefficients reported in Panel B, columns 3 and 4, show that by 1852, relative to low-blight baronies, high- and medium-blight baronies with £1000 more in average annual Loan Fund lending during the famine had increased the fraction of acreage allocated to other crops by 9 and 6 percentage points more, respectively, than high- and medium-blight baronies without.

2SLS estimates of Eq. (3.2) at the PLU level, reported in Panel A, column 5 of Table 3.6, indicate that Loan Fund activity had a very large effect on crop acreage reallocation during the famine years, particularly

following two successive crop failures. After an 11.4-percentage point larger relative decline in the potato crop's share of total acreage under tillage crop in 1846, in 1847, medium-high-blight PLUs with a Loan Fund had, relative to low-medium-blight PLUs, reduced the potato's share of total crop acreage by an estimated 39.4 percentage points more than medium-high-blight PLUs without a fund. By 1852, relative to low-medium-blight PLUs, medium-high-blight PLUs with a Loan Fund had relatively reduced the fraction of total tillage acreage under potato crop by 34.6 percentage points.

Estimated coefficients for the main effects of medium- and high-blight infection (β_{1t}'s and β_{2t}'s from Eq. (3.1) and β_{1t}'s from Eq. (3.2)) on average changes in population, crop acreage, and farmholdings are reported in Table 3.7. Results indicate that the main effects of more severe blight infection remain large and statistically significant even after controlling for the main and interactive effects of differential access to Loan Fund credit.

2SLS-estimated coefficients reported in Panel A, columns 1 and 2 of Table 3.8, indicate that Loan Funds again also had significant effects on relative changes in buffer livestock holdings by farms under 15 acres. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with a Loan Fund had increased the value of buffer livestock holdings by £193.21 and £157.11 more, respectively, than farms under 15 acres in high- and medium-blight baronies without a fund. By the end of the famine, in 1852, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with a Loan Fund had increased the value of buffer livestock holdings by £673.23 and £532.62 more, respectively, than farms under 15 acres in high- and medium-blight baronies without a fund.

Table 3.7 Estimated changes in population, potato crop share, and farm size by blight severity, with instrumented Loan Fund presence and lending

	Population (levels)		Potato crop share			<5 Acres farm share
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Medium-high vs. low-medium (PLU)	Medium-high vs. low-medium (PLU)
	(1)	(2)	(3)	(4)	(5)	(6)
A. Loan Fund presence						
1846			−0.039*	−0.038*	−0.011	
			(0.02)	(0.02)	(0.01)	
1847					−0.122**	
					(0.06)	
1848					−0.160**	−0.155**
					(0.06)	(0.06)
1849					−0.132**	−0.139**
					(0.07)	(0.06)
1851	−7669.09***	−4794.833***				
	(2125.702)	(1481.241)				
1852			−0.159*	−0.157*	−0.107**	−0.096*
			(0.08)	(0.08)	(0.05)	(0.05)
1856			−0.175**	−0.174*	−0.122**	−0.076
			(0.08)	(0.09)	(0.05)	(0.05)
B. Average annual lending						
1846			−0.044**	−0.032*		
			(0.02)	(0.02)		

(*continued*)

Table 3.7 (continued)

	Population (levels)		Potato crop share			<5 Acres farm share
	High vs. low	Medium vs. low	High vs. low	Medium vs. low	Medium-high vs. low-medium (PLU)	Medium-high vs. low-medium (PLU)
	(1)	(2)	(3)	(4)	(5)	(6)
1851	−5938.061***	−3353.013**				
	(2250.502)	(1405.328)				
1852			−0.087**	−0.055*		
			(0.04)	(0.03)		
1856			−0.101***	−0.068***		
			(0.03)	(0.03)		
N	188		206		93	93
R2	0.660 (A) 0.593 (B)		0.532 (A) 0.420 (B)		0.230	0.163

Notes: Each column reports estimated coefficients ($\beta_{1,2t}$'s and β_{1t}'s from Eqs. (3.1) and (3.2) in the text, representing main effects of blight) for changes in the indicated outcome variable in the indicated year by blight severity, where blight severity is also interacted with Loan Fund presence during the famine (Panel A) or with average annual Loan Fund lending from 1845 through 1850 (Panel B), and Loan Fund presence or average annual lending during the famine instrumented by AIMS musical society presence. Loan Fund presence (Panel A) or average annual lending (Panel B) during the famine is also fully interacted with available pre-famine lags of the indicated outcome variable. All baronial-level regressions control for area, partial adult literacy in 1841, pre-famine baronial valuation, total population in 1841, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. All PLU-level regressions control for area, pre-famine valuation, 1841 population, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total PLU border length shared with other PLUs with at least one Loan Fund during the famine, and county. Robust standard errors are reported in parentheses and clustered at the baronial or PLU level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 3.8 2SLS-estimated changes in value of livestock holdings by blight severity interacted with Loan Fund presence

	Farms under 15 acres		*Farms over 15 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)
A. Buffer livestock				
1848	193.211**	157.113*	vr1450.459*	−1480.063*
	(94.91)	(87.79)	(839.43)	(837.71)
1849	431.935*	328.071	−2136.56	−2121.841
	(242.67)	(231.93)	(1353.05)	(1361.38)
1850	349.842	313.849	−1500.999	−1504.49
	(247.23)	(240.34)	(1224.01)	(1233.40)
1852	673.227**	532.616*	−980.354	−1129.179
	(323.42)	(318.24)	(816.60)	(829.58)
1856	549.098*	338.390	−818.931**	−982.650**
	(327.64)	(314.81)	(397.49)	(403.80)
B. Grazing livestock				
1848	91.805	1011.561	817.163	830.743
	(1588.66)	(1540.03)	(5023.58)	(5090.53)
1849	1182.225	1327.150*	−604.995	−2860.687
	(987.93)	(750.33)	(4954.90)	(4917.37)
1850	1246.026	1047.958	2657.720	303.123
	(1397.89)	(1096.63)	(10266.29)	(10262.28)
1852	958.962	471.898	7255.148	2192.640
	(1806.82)	(1627.73)	(10716.37)	(10736.68)
1856	3486.400*	3049.080*	9572.528	4322.139
	(2025.03)	(1615.17)	(9757.95)	(9774.53)
N	202		202	
R2	0.261 (A) 0.190 (B)		0.460 (A) 0.441 (B)	

Notes: Each column reports 2SLS-estimated coefficients (β_{4t}'s and β_{5t}'s from Eq. (3.1) in the text) for changes in the value of holdings of buffer (swine and poultry) livestock (Panel A) and grazing (cattle, sheep, and goats) livestock (Panel B), subdivided by farm size, in the indicated year by blight severity interacted with Loan Fund presence during the famine, with Loan Fund presence instrumented by AIMS musical society presence. All regressions control for area, partial adult literacy in 1841, 1841 population, pre-famine baronial valuation, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

While Loan Funds generally again do not appear to have been associated with short-run relative accumulations of grazing stock by farms under 15 acres in high- and medium-blight baronies, 2SLS-estimated coefficients reported in Panel B, columns 1 and 2 of Table 3.8, indicate they were associated with greater medium-run substitutions toward pasture. By 1856, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with a Loan Fund had increased the value of grazing livestock by £3486.40 and £3049.08 more, respectively, than farms under 15 acres in high- and medium-blight baronies without a fund.

In contrast to farms under 15 acres, 2SLS-estimated coefficients reported in Panels A and B, columns 3 and 4 of Table 3.8, reveal that farms over 15 acres in high- and medium-blight baronies with a Loan Fund generally did not experience systematically different relative increases in either buffer or grazing livestock holdings compared to farms over 15 acres in high- and medium-blight baronies without a Loan Fund. In fact, it appears that Loan Fund presence during the famine may actually have been associated with reductions in buffer livestock holdings by farms over 15 acres in high- and medium-blight baronies, relative to farms over 15 acres in low-blight baronies.

Estimated coefficients for the main effects of medium- and high-blight infection (β_{1t}'s and β_{2t}'s from Eq. (3.1)) on average changes in buffer and grazing livestock holdings by farm size are reported in Table 3.9. Results indicate that the main effects of more severe blight infection remain large and statistically significant even after controlling for the main and interactive effects of differential access to Loan Fund credit.

3.3.4 Additional Robustness Checks

In Sect. 1.2, I showed that pre-famine baronial and PLU characteristics were poor predictors of blight severity and Loan Fund presence, lending, and AIMS musical society presence. As an additional robustness check, I also estimate Eqs. (3.1) and (3.2) for average changes in outcome variables before the famine, in order to check whether pre-trends differed systematically in worse versus less severely infected baronies, and worse

Table 3.9 Estimated changes in value of livestock holdings by blight severity, with instrumented Loan Fund presence

	Farms under 15 acres		*Farms over 15 acres*	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)
A. Buffer livestock				
1848	215.330**	111.978	1353.794	1284.812
	(87.63)	(93.65)	(933.24)	(935.92)
1849	546.416**	389.003	1888.925	1758.459
	(235.88)	(236.42)	(1218.90)	(1219.88)
1850	474.347**	360.536	1384.301	1235.542
	(235.21)	(240.36)	(916.23)	(818.71)
1852	747.858**	559.447*	1013.857	826.042
	(316.83)	(317.11)	(657.38)	(564.17)
1856	612.578*	456.251	559.209	328.498
	(316.83)	(319.05)	(339.02)	(251.67)
B. Grazing livestock				
1848	232.264	−1116.465	−826.963	−1463.953
	(1525.75)	(1679.25)	(4877.84)	(4935.79)
1849	252.638	−1060.55	3962.139	3567.265
	(738.81)	(1068.35)	(4408.95)	(4299.12)
1850	453.892	−923.825	4848.711	2038.171
	(1144.60)	(1307.72)	(9873.10)	(9894.84)
1852	487.948	−673.422	−4652.882	−4660.178
	(1606.86)	(1728.34)	(9612.77)	(9628.40)
1856	2926.416*	1593.514	−4181.126	−5073.327
	(1647.90)	(1744.17)	(9013.83)	(8980.89)
N	202		202	
R2	0.261 (A) 0.190 (B)		0.460 (A) 0.441 (B)	

Notes: Each column reports estimated coefficients (β_{1t}'s and β_{2t}'s from Eq. (3.1) in the text, representing main effects of blight) for changes in the value of holdings of buffer (swine and poultry) livestock (Panel A) and grazing (cattle, sheep, and goats) livestock (Panel B), subdivided by farm size, in the indicated year by blight severity, with Loan Fund presence instrumented by AIMS musical society presence. All regressions control for area, partial adult literacy in 1841, 1841 population, pre-famine baronial valuation, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

infected baronies with a Loan Fund versus those without. Unfortunately, since farm size data is not available before 1845 and livestock data is not available before 1847, it is only possible to analyze pre-trends in average changes in population from 1821 to 1831 and 1831 to 1841, and potato crop share from 1844 to 1845. Results are presented in Table 3.11.

Estimated coefficients reported in Panel A, columns 1 and 2 of Table 3.11, reveal that, relative to baronies suffering low-blight infection in 1845 and 1846, baronies suffering high or medium infection had not experienced systematically different changes in population before the arrival of blight. Estimated coefficients reported in Panel A, columns 3 and 4, similarly show that relative to low-blight baronies, baronies suffering high or medium infection had not experienced systematically different changes in acreage allocation to the potato; the average change in potato crop acreage as a fraction of all acres under tillage between 1844 and 1845 was statistically no different in high- and medium-blight baronies versus low-blight baronies.

Estimated coefficients reported in Panel B, columns 1 and 2 of Table 3.11, show that, relative to baronies suffering low-blight infection in 1845 and 1846, high- and medium-blight baronies with a Loan Fund had not experienced systematically different pre-blight relative changes in population than high- and medium-blight baronies without a fund. Likewise, estimated coefficients reported in Panel B, columns 3 and 4, show that, relative to low-blight baronies, high- and medium-blight baronies with a Loan Fund had not experienced systematically different changes in acreage allocation to the potato versus high- and medium-blight baronies without; the average relative change in potato crop acreage as a fraction of all acres under tillage between 1844 and 1845 was statistically no different in high- and medium-blight baronies with a Loan Fund than in those without. These results can also be observed in Fig. 3.1, with estimated coefficients plotted in Panels A, B, and C of Fig. 3.1 for average changes in population and potato crop share revealing no systematically different pre-famine trends in high- and medium-blight baronies or medium-high PLUs with a Loan Fund versus those without, relative to low-blight baronies or low-medium PLUs.

Table 3.10 First-stage estimated coefficients on AIMS musical society presence and AIMS interacted with blight severity

	Fund	Fund × blight-medium	Fund × blight-high	Lending	Lending × blight-medium	Lending × blight-high
	(1)	(2)	(3)	(4)	(5)	(6)
A. Population						
Music	1.053***	0.063	−0.010	3612.266	−120.905	−1771.157
	(0.12)	(0.08)	(0.08)	(3234.85)	(520.12)	(1872.47)
Music × blight-medium	−0.411***	0.608***	−0.019	−2918.837	1581.673**	868.218
	(0.10)	(0.09)	(0.05)	(2821.00)	(756.26)	(1027.11)
Music × blight-high	−0.246**	−0.014	0.768***	−482.531	236.029	4622.191***
	(0.10)	(0.05)	(0.08)	(2819.49)	(310.49)	(1204.01)
N	188	188	188	188	188	188
R2	0.560	0.661	0.700	0.351	0.350	0.445
B. Potato crop share						
Music	1.025***	0.078	−0.053	3321.136	190.243	−2331.512
	(0.13)	(0.08)	(0.10)	(3272.65)	(377.65)	(2187.07)
Music × blight-medium	−0.425***	0.561***	0.014	−2994.914	1313.931**	994.863
	(0.11)	(0.10)	(0.05)	(2536.29)	(623.29)	(969.29)
Music × blight-high	−0.224***	−0.033	0.809***	−956.981	41.917	4196.380***
	(0.08)	(0.04)	(0.07)	(2384.29)	(217.04)	(945.65)
N	206	206	206	206	206	206
R2	0.544	0.620	0.701	0.303	0.328	0.406

(*continued*)

Table 3.10 (continued)

	Fund	Fund × blight-medium	Fund × blight-high	Lending	Lending × blight-medium	Lending × blight-high
	(1)	(2)	(3)	(4)	(5)	(6)
C. Livestock						
Music	0.981***	0.005	−0.010	4414.467*	−113.994	−722.566
	(0.06)	(0.04)	(0.08)	(2242.65)	(242.84)	(780.86)
Music × blight-medium	−0.409***	0.588***	−0.019	−3273.57	1268.758**	757.799
	(0.10)	(0.09)	(0.05)	(2321.62)	(623.15)	(756.93)
Music × blight-high	−0.215***	−0.018	0.768***	−966.647	−89.136	4370.712***
	(0.07)	(0.04)	(0.08)	(2282.83)	(217.81)	(901.03)
N	202	202	202	202	202	202
R2	0.547	0.622	0.700	0.355	0.341	0.425

Notes: Each column reports first-stage estimated coefficients at the baronial level for Loan Fund presence and average annual Loan Fund lending from 1845 through 1850 and Loan Fund presence and lending interacted with blight severity, instrumented by AIMS musical society presence, AIMS musical society presence interacted with blight severity and available pre-famine lags of the indicated outcome variable, and the fraction of total baronial border length shared with other baronies with an AIMS musical society. All regressions control for area, partial adult literacy in 1841, pre-famine baronial valuation, total population in 1841, the 1841 share of housing rated fourth class, pre-famine potato acreage as a fraction of total tillage acreage, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 3.11 Estimated pre-famine changes in population and potato crop share by blight severity and Loan Fund presence

	Population		Potato crop share	
	High vs. low	Medium vs. low	High vs. low	Medium vs. low
	(1)	(2)	(3)	(4)
Panel A: Blight severity				
1831	0.0380	0.061		
	(0.08)	(0.08)		
1841	−0.016	0.009		
	(0.09)	(0.08)		
1845			−0.031	0.020
			(0.03)	(0.03)
Panel B: Loan fund				
1831	−0.054	−0.026		
	(0.14)	(0.14)		
1841	−0.026	−0.022		
	(0.15)	(0.14)		
1845			0.041	0.067
			(0.06)	(0.06)
N	188		206	
R2	0.257 (A) 0.301 (B)		0.508 (A) 0.501 (B)	

Notes: Each column reports estimated coefficients for pre-famine changes in log population and the fraction of total tillage acres under potato crop in the indicated year by blight severity (Panel A) and by blight severity and Loan Fund presence (Panel B). All regressions control for any preceding observations of outcome variables, area, partial adult literacy in 1841, baronial valuation, the share of housing rated fourth class, and PLU and county. Robust standard errors are reported in parentheses and clustered at the baronial or PLU level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

3.4 Conclusion

Microfinance credit from the Irish Loan Funds played a significant role in non-demographic adjustment to blight. Relative to moderately affected baronies, severely affected baronies with at least one active Loan Fund during the famine years experienced 42.1% smaller population declines by 1851 than severely impacted baronies without. Loan Fund lending in severely affected districts during the famine was associated with larger and earlier substitutions toward other tillage crops and increases in temporary buffer stocks of pigs and poultry than in severely affected districts with less lending. Specifically, during the famine, relative to

low-medium-impact PLUs, medium- to-high-impact PLUs with a Loan Fund increased the fraction of total tillage acreage under other crops by 54.6 percentage points more by 1847 than medium-high-impact PLUs without. By the end of the famine, the relative decrease in the potato's share of total crop acreage was 34.3 percentage points greater in medium-high-impact PLUs with a Loan Fund versus in those without.

Finally, during and immediately after the famine, small- to medium-sized farms in severely infected baronies with a Loan Fund experienced significant relative increases in holdings of buffer stocks of pigs and poultry; by 1852, farms of 1 to 5 acres in severely infected baronies with a Loan Fund had increased stocks of pigs and chickens relative to moderately infected baronies by 133.3 and 82.3 percentage points more, respectively, than farms of 1 to 5 acres in severely impacted baronies without a fund. Also by 1852, relative to small- to medium-sized farms in moderately infected baronies, small- to medium-sized farms of 5 to 15 acres in severely and considerably infected baronies with a Loan Fund had increased holdings of cattle by 31.1 and 28.5 percentage points, respectively, than 5–15-acre farms in severely and considerably infected baronies without a fund. Loan Funds do not appear to have had any effect on differential relative changes in livestock holdings by farms larger than 15 acres. All of these estimates are robust to analysis by two-stage least squares regression.

The results of this chapter suggest that access to credit plays a profound role in short- and medium-run adjustment to adverse environmental shocks in a subsistence or near-subsistence economy. The long-run non-demographic adaptations to the arrival of blight in Ireland, specifically crop portfolio diversification and substitutions away from tillage toward pasture, were effected earlier and to a greater extent in worse affected districts with a microcredit lender versus those without. Moreover, in the presence of incomplete capital markets, access to microcredit appears to have allowed farmers to acquire temporary stocks of buffer livestock assets that could be easily liquidated in the event of crop failure and thereby smooth consumption. Microfinance appears, however, to have had a limited effect on economic adjustment by the smallest farmers, which suggests that other forms of relief may be necessary to mitigate the effects of adverse environmental change on the most vulnerable populations.

3.5 Appendix 3.1

3.5.1 Acreage Allocation with Constrained Credit

The farmer's optimization problem is to maximize $\pi(\psi, \Sigma)$, where

$$\psi \equiv \psi_{it} A_{it} + \psi_{jt}\left(\bar{A} - A_{it}\right) - r\left(\left|A_{it} - A_{it-1}\right| k + c_{it} A_{it} + c_{jt}\right)\left(\bar{A} - A\right) - \omega_t$$
$$\text{s.t.}\left(\left|A_{it} - A_{it-1}\right| k + c_{it} A_{it} + c_{ij}\left(\bar{A} - A\right)\right) \le \omega_t + \bar{K}$$

For $A_{it} > A_{it-1}$, the first-order condition is

$$\partial\pi / \partial A_{it} = \pi_{\psi}\left(\left(\psi_{it} - \psi_{jt}\right) - r\left(k + \left(c_{it} - c_{jt}\right)\right)\right) + 2\pi \begin{pmatrix} \left(\lambda_i^2 + \sigma_{it}^2\right) A_{it} - \left(\lambda_j^2 + \sigma_{jt}^2\right)\left(\bar{A} - A_{it}\right) \\ + \left(\bar{A} - 2A_{it}\right)\left(\lambda_i + \sigma_{it}\right)\left(\lambda_j + \sigma_{jt}\right)\rho_{ij} \end{pmatrix} = 0$$

Using $\rho_{ij} = \dfrac{\text{cov}\left(\eta_{it}, \eta_{jt}\right)}{\left(\lambda_i + \sigma_{it}\right)\left(\lambda_j + \sigma_{jt}\right)}$, we can simplify this expression and solve for A_{it}:

$$\hat{A}_{it}^{*} = \frac{\pi_{\psi}\left(\left(\psi_{it} - \psi_{jt}\right) - r\left(k + \left(c_{it} - c_{jt}\right)\right)\right) - 2\pi_{\Sigma}\left(\bar{A}\left(\lambda_j^2 + \sigma_{jt}^2\right) + 2\bar{A}\,\text{cov}\left(\eta_{it}, \eta_{jt}\right)\right)}{2\pi_{\Sigma}\left(\left(\lambda_i^2 + \sigma_{it}^2\right) + \left(\lambda_j^2 + \sigma_{jt}^2\right) - 2\text{cov}\left(\eta_{it}, \eta_{jt}\right)\right)}$$

Taking the derivative of $\hat{A}_{it}^{*}$ with respect to r then yields

$$\frac{\partial \hat{A}_{it}^{*}}{\partial r} = \frac{\pi_{\psi}\left(k + \left(c_{it} - c_{jt}\right)\right)}{2\pi_{\Sigma}\left(\left(\lambda_i^2 + \sigma_{it}^2\right) + \left(\lambda_j^2 + \sigma_{jt}^2\right) - 2\text{cov}\left(\eta_{it}, \eta_{jt}\right)\right)}$$

So long as the sum of the variances of crops i and j is greater than twice the covariance of the disturbance terms, the denominator is negative, by the assumption of risk aversion ($\pi_{\Sigma} < 0$). So long as the variances of the

two crops are not identical, this will always be true. We thus have that $\partial \hat{A}_{it}^{*}/\partial r < 0$ if $c_{jt} < k + c_{it}$.

3.5.2 Allocation with Livestock as a Buffer Stock

The farmer now maximizes $\pi(\psi, \Sigma)$, where

$$\psi \equiv \psi_{it} A_{it} + \psi_{jt}\left(\overline{A} - A_{it}\right) + \left(p_{Lt} - c_{Lt}\right) \times \left(L_t - r\left(\left|A_{it} - A_{it-1}\right| k + c_{it} A_{it} + c_{jt}\left(\overline{A} - A\right) + c_{Lt} L_t - \omega_t\right)\right)$$

and

$$\Sigma \equiv \left(\lambda_i^2 + \sigma_{it}^2\right) A_{it}^2 + \left(\lambda_j^2 + \sigma_{jt}^2\right)\left(\overline{A} - A_{it}\right)^2 + 2A_{it}\left(\overline{A} - A_{it}\right)\left(\lambda_i + \sigma_{it}\right)\left(\lambda_j + \sigma_{jt}\right)\rho_{ij}$$

Assuming the credit constraint is binding, we set up the Lagrangian

$$\min_{\lambda} \max_{\pi} \Lambda\left(\pi\left(\psi, \Sigma\right), \lambda\right) = \pi\left(\psi, \Sigma\right) + \lambda\left(\left(\omega_t + \overline{K}\right) - \left|A_{it} - A_{it-1}\right| k - c_{it} A_{it} - c_{jt}\left(\overline{A} - A_{it}\right) - c_{Lt} L_t\right)$$

For $A_{it} > A_{it-1}$, we have first-order conditions

$$\frac{\partial}{\partial A_{it}} = \pi_{\psi}\left(\left(\psi_{it} - \psi_{jt}\right) - r\left(k + \left(c_{it} - c_{jt}\right)\right)\right) + 2\pi\left(\left(\lambda_i^2 + \sigma_{it}^2\right) A_{it} - \left(\lambda_j^2 + \sigma_{jt}^2\right)\left(\overline{A} - A_{it}\right) + \left(\overline{A} - 2A_{it}\right)\left(\lambda_i + \sigma_{it}\right)\left(\lambda_j + \sigma_{jt}\right)\rho_{ij}\right) = 0$$

$$\frac{\partial}{\partial L_t} = \pi_{\psi}\left(\left(p_{Lt} - c_{Lt}\right) - \left(1 + r\right) c_{Lt}\right) = 0$$

$$\frac{\partial}{\partial \lambda} = \left(\omega_t + \overline{K}\right) - \left(\left|A_{it} - A_{it-1}\right|\right) k - c_{it} A_{it} - c_{jt}\left(\overline{A} - A_{it}\right) - c_{Lt} L_t = 0$$

Using substitution and solving for $\hat{A}_{it}^{*}$ and L_t^{*}, we find that for $\hat{A}_{it}^{*} > A_{it-1}$, the derivative of L_t^{*} with respect to r is then

$$\frac{\partial L_t^{*}}{\partial r} = -\frac{\pi_{\psi}\left(k+\left(c_{it}-c_{jt}\right)\right)\left(k+\left(c_{it}-c_{jt}\right)-c_{Lt}\right)}{2c_{Lt}\pi_{\Sigma}\left(\left(\lambda_i^2+\sigma_{it}^2\right)+\left(\lambda_j^2+\sigma_{jt}^2\right)-2\mathrm{cov}\left(\eta_{it},\eta_{jt}\right)\right)}$$

So long as the sum of the variances of crops i and j is greater than twice the covariance of the disturbance terms (which, assuming the variances are unequal, is always true), the denominator is negative, by the assumption of risk aversion ($\pi_{\Sigma} < 0$). We thus see that $\partial L_t^{*} / \partial r < 0$ if $c_{Lt} > k + (c_{it} - c_{jt})$ and $c_{jt} < k + c_{it}$ or $c_{Lt} < k + (c_{it} - c_{jt})$ and $c_{jt} > k + c_{it}$. Substituting the fourth expression into the third, we see that the second inequality pair implies a negative unit cost of livestock, which we can realistically assume will never be the case.

The derivative of L_t^{*} with respect to σ_{jt} is

$$\frac{\partial L_t^{*}}{\partial \sigma_{jt}} = \left(\begin{array}{l}\pi_{\psi}\left(\left(\,p_{Lt}-c_{Lt}\right)-\left(\psi_{it}-\psi_{jt}\right)+r\left(k+\left(c_{it}-c_{jt}\right)-c_{Lt}\right)\right.\\ \left.+2\sigma_{jt}\bar{A}\pi_{\Sigma}\left(\mathrm{cov}\left(\eta_{it},\eta_{jt}\right)-\lambda_i^2-\sigma_{it}^2\right)\right)\end{array}\right) \times \left(\frac{\left(k+\left(c_{it}-c_{jt}\right)\right)}{c_{Lt}\pi_{\Sigma}\left(\left(\lambda_i^2+\sigma_{it}^2\right)+\left(\lambda_j^2+\sigma_{jt}^2\right)-2\mathrm{cov}\left(\eta_{it},\eta_{jt}\right)\right)^2}\right)$$

By the assumption of risk aversion ($\pi_{\Sigma} < 0$), the common denominator is negative, which means, provided $c_{jt} < k + c_{it}$, if $0 > \partial L_t^{*} / \partial \sigma_{jt}$, then

$$\pi_{\Sigma} < \frac{\pi_{\psi}\left(\left(\left(\psi_{it}-\psi_{jt}\right)-r\left(k+\left(c_{it}-c_{jt}\right)\right)\right)-\left(\left(p_{Lt}-c_{Lt}\right)-rc_{Lt}\right)\right)}{2\sigma_{it}\overline{A}\left(\operatorname{cov}\left(\eta_{it},\eta_{jt}\right)-\left(\lambda_{i}^{2}+\sigma_{it}^{2}\right)\right)}$$

As long as $\sigma_{it}^{2} > 0$, the denominator of the above expression is always negative. The numerator, which represents the difference in the marginal net benefit between crop i and livestock holding, we can assume, is positive, as otherwise the farmer should have no incentive to cultivate a risky crop i versus raising assumed zero-risk livestock. Thus, the right-hand side of the above expression is negative, consistent with the assumption of risk aversion ($\pi_{\Sigma} < 0$).

The derivative of L_t^* with respect to λ_j can be obtained analogously, with $\partial L_t^*/\partial\lambda_j > 0$ if

$$\pi_{\Sigma} < \frac{\pi_{\psi}\left(\left(\left(\psi_{it}-\psi_{jt}\right)-r\left(k+\left(c_{it}-c_{jt}\right)\right)\right)-\left(\left(p_{Lt}-c_{Lt}\right)-rc_{Lt}\right)\right)}{2\sigma_{it}\overline{A}\left(\operatorname{cov}\left(\eta_{it},\eta_{jt}\right)-\left(\lambda_{i}^{2}+\sigma_{it}^{2}\right)\right)}$$

4

Surviving the Famine

> The report of the Board states, that the loss on the operations of the year has been so great in a vast number of societies, as to exceed the net profits in the aggregate. The deficiency is attributed to the disorganized state of the country, arising from the past years of famine and distress; many borrowers and sureties, who were considered solvent when the loans were issued, having become paupers prior to the loans being payable. Also, though prompt steps were taken by the local managers to contract the circulation by diminishing the issues, they could not as suddenly contract their scale of expenses adapted for double or treble the business. The same cause, it is alleged, accounts for the enormous proportionate cost on the issue of each loan, as compared with the operations of more prosperous years. A considerable falling off in the circulation has taken place in consequence of the distressed state of the country—*Thom's Directory of Ireland* (1850)

A major potential challenge confronting microfinance lenders, cooperatives, and credit-granting NGOs is that they may be ill-equipped to absorb the kinds of large covariate shocks typical of agricultural loan portfolios (Binswanger and Rosenzweig 1986; Braverman and Guasch 1986; Rosenzweig 1988; Shoji 2010; Kurosaki and Khan 2012). While recent research has demonstrated that access to microfinance credit can mitigate

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T.B. Goodspeed, *Famine and Finance*,
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the impact of environmental shocks on income and consumption (Dercon 2002; Khandker 2007; Becchetti and Castriota 2008; Goodspeed 2016a), the ability of microfinance lenders to cope with large-scale aggregate shocks involving high spatial correlation in income effects and default risk remains understudied. This is a significant gap in the extensive microfinance literature—which has tended to focus on welfare effects and optimal models of sustainability under ordinary lending circumstances—because the concentration of borrowers and depositors in contiguous geographic locales and identical crop portfolios can generate considerable covariate risk for microfinance institutions, for example, following adverse environmental change (Miamidian et al. 2005). MFIs may therefore be most vulnerable where and when they are most needed (Berg and Schrader 2012). History offers a unique opportunity to observe such rare events, and to analyze differential MFI outcomes and adjustment strategies, over both the short and long runs, in order to identify how sustainable lending models may vary depending on the macro context.

Following Hollis and Sweetman (2004) and utilizing a new dataset constructed by Goodspeed (2016a), this chapter thus analyzes on the Loan Funds. I find that compared to funds operating in less infected districts, funds in districts worse affected by blight in 1845 and 1846 not only had lower predicted probabilities of survival and experienced greater declines in lending, capital, and depositors, but also experienced larger declines in average interest rates, penalty fines on loans, and bad debts. Borrowing costs for qualifying borrowers therefore fell as funds in worse affected districts contracted lending and significantly raised credit standards.

I further find that pre-famine balance sheet metrics were important predictors of institutional survival during the famine, though certain metrics that were generally associated with higher (lower) survival probabilities were associated with lower (higher) survival probabilities where the severity of the environmental shock was greater. Specifically, while greater leverage, lower average staff salaries, and more depositors were generally associated with higher predicted probabilities of institutional survival, the reverse was true where blight infection was more severe. Conversely, though a higher average pre-famine unit cost of credit intermediation was generally associated with a lower predicted

survival probability, in the face of severe blight infection funds with higher expenses as a percentage of total lending before the famine were more likely to survive the first two years of blight.

Funds with higher pre-famine gross profit margins per loan were generally no more likely to survive long-term than less profitable funds, but higher pre-famine margins were positive predictors of institutional survival where blight infection was worse. While ministers were generally less competent fund managers—funds managed by ministers had a significantly lower predicted probability of survival—ministers were statistically no more or less competent than non-clergy managers where the magnitude of the environmental shock was greater. Differences in average pre-famine loan size, bad debts, fines ratio, number of loans, and cost of capital do not appear to have had differential effects on predicted survival probabilities during and immediately after the famine, either generally or particularly where blight infection was more severe.

I additionally find that differences in pre-famine balance sheet metrics were associated with differential institutional responses to the adverse shock. Specifically, relative to funds with lower average gross profit margins per loan before the famine, funds in worse affected districts with higher pre-famine margins relatively reduced average loan size, interest rates, fines ratios, and bad debts during the famine, implying a relative increase in average credit quality among approved borrowers. Similarly, funds in worse affected districts with higher staff salaries before the famine relatively reduced their average annual number of loans and fines ratios during the famine. Moreover, while funds with higher pre-famine profit margins experienced relative declines in average margin per loan, there was no difference in their average, non-differenced level of profit margin per loan during the famine. In contrast, funds in worse affected districts with more depositors before the famine experienced relative increases in average loan size, fines ratios, and bad debts during the famine, while funds in worse affected districts that had been more highly levered before the famine experienced a relative rise in the unit cost of credit intermediation and relative decline in profitability, resulting in lower average margins per loan during the famine. In robustness checks, I find that differences in pre-famine balance sheet metrics cannot be explained by pre-famine differences in available micro-level social and economic variables.

These findings suggest that MFIs that had been earning higher rents before the famine had more scope to contract credit and raise lending standards in response to an adverse spatially correlated shock, while still remaining profitable. Better compensated staffs seem to have been more effective at restricting credit to higher-quality borrowers. In contrast, funds that had been relying more heavily on leverage appear to have been more severely affected by balance sheet contraction during the famine, with more levered funds experiencing relative increases in the unit cost of credit intermediation and relative decreases in average profit margin per loan, resulting in lower average margins during the famine. Funds with more depositors, meanwhile, seem to have been less able to contract their lending portfolios and raise average credit standards. These results imply that MFI sustainability in the face of a major covariate shock such as a natural disaster may depend critically on an ability to rapidly scale down lending, reduce average loan size, and significantly raise lending standards, and therefore that though microfinance may help to mitigate the effects of such shocks on borrowers of higher credit quality, it is not a viable mitigant for more vulnerable borrowers.

The organization of the remainder of this chapter is as follows. Section 4.1 develops a theoretical model for analyzing the effects of an aggregate shock on credit supply in a relationship lending context. Section 4.2 details the empirical framework, while Sect. 4.3 presents the results and robustness checks. Section 4.4 concludes.

4.1 Theoretical Framework

A central challenge confronting MFIs, particularly in developing contexts, is the high degree of asymmetric information concerning the creditworthiness of potential borrowers. The problem is especially acute for MFIs, such as the Irish Loan Funds, that extend loans on zero collateral. Like more contemporary lenders in the business of lending to potentially high-risk borrowers, many Loan Funds therefore relied on relationship-based lending to overcome informational asymmetry, accumulating "soft" information on borrower creditworthiness through weekly repayment records and repeat lending (Piesse 1841; Petersen

and Rajan 1994; Berger and Udell 1995, 2002; Cole 1998; Chakravarty and Scott 1999; Cole et al. 2004; Chakravarty and Yilmazer 2009; McLaughlin 2009).[1] Following Petersen and Rajan (1995) and Berg and Schrader (2012), I therefore frame the Loan Fund model in the context of relationship lending.

For simplicity, I assume a risk-neutral world. The number of households is normalized to 1, with each household holding different initial amounts of capital, k_n. The distribution of capital across households is described by the cumulative distribution function $G(k)$, so that the aggregate volume of household capital is $K = \int_0^\infty G(k)dk$.[2] At the start of period $t=0$, households apply to an MFI lender for a loan so as to invest an amount $I_0 > k_n$ in a project that pays out Y_0 at the end of the period if the borrower is a "good" entrepreneur, and 0 otherwise. At the start of $t=1$, good entrepreneurs will then be able to borrow $I_1 > Y_0 + k_n$ to invest in a second project paying out Y_1 at the end of $t=1$.

I assume that at the start of $t=0$, only prospective borrowers know whether they are good or bad entrepreneurs; MFI lenders know only that a fraction θ_n of borrowers are good entrepreneurs who will repay their loan in full, with interest, at the end of the first period and return for another loan to invest in the second period. θ_n is thus the *ex ante* credit quality of borrowers. At the start of $t=0$, the lender therefore offers a standard debt contract with an interest rate of r. But at the end of $t=0$, the lender becomes fully informed of the type of borrower it is dealing with and can therefore charge returning borrowers a safe rent $R < r$.

The lender's problem is then to determine the optimal interest rate r^* that satisfies:

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[1] McLaughlin (2009) cites the account book of the Knockmourne Loan Fund, where the number of borrowers was approximately 20% of the number of loans extended, implying many borrowers were repeat clients.

[2] In other words, $G(k)$ is the fraction of households with assets less than k. The fraction N of households requiring external financing is thus equal to $G(I)$, meaning total loan demand is $\int_0^1 G(I)I - G(k)dk$.

$$\theta r\left(I_0 - k_n\right) + \theta R\left(I_1 - k_n - Y_0\right) - \left(1-\theta\right)\left(I_0 - k_n\right) \geq 0$$

Borrowers, meanwhile, will only take out a loan if the net return is positive, meaning:

$$Y_0 + Y_1 - I_0 - I_1 - r\left(I_0 - k_n\right) - R\left(I_1 - k_n - Y_0\right) \geq 0$$

The MFI thus faces a trade-off—raising r yields higher revenue in the first period, but lowers the rents it could earn in the second by reducing the viability of investment projects potentially undertaken by good entrepreneurs. From these positive net income constraints, it is then easy to derive the optimal interest rate (r^*) and lowest credit quality (θ^*) at which the MFI is able to lend without making losses:

$$r^* = \frac{Y_0 + Y_1 - I_0 - I_1 - \left(1-\theta\right)\left(I_0 - k_n\right) - \left(1-\theta\right)R\left(I_1 - k_n - Y_0\right)}{\left(1-\theta\right)\left(I_0 - k_n\right)}$$

$$\theta^* = \frac{\left(1+r\right)\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right) - \left(Y_0 + Y_1 - I_0 - I_1\right)}{\left(1+r\right)\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right)}$$

Supposing an aggregate income shock occurs before prospective borrowers apply for loans in $t = 0$, there are three channels through which lending may be affected. The first is the direct impact on household capital assets, k_n. In a subsistence economy such as 1840s' Ireland, this would largely comprise drawdowns of stocks of seed potatoes, grain stores, and/or liquidation of livestock assets and durable goods. The second channel consists of the indirect losses of lower revenues at the end of $t = 0$ (i.e., Y_0), implying smaller flows of intermediate goods for production in period $t = 1$, while the third channel consists of the macroeconomic effects of lower investment returns in later periods (Y_1). In the context of 1840s' Ireland, indirect losses would likely consist primarily of lower year-end stores of fodder and seed, while macroeconomic losses would consist of lower revenues owing to a decline in aggregate income. Since investment projects with negative net present values will not be undertaken, I assume

that the effects of the shock on Δk_n, ΔY_0, and ΔY_1 are not so large as to render projects unprofitable.[3]

Proposition 1 *After an adverse aggregate shock, the fraction of loan applicants receiving a loan will decrease.*

Proof An aggregate income shock will result in a decline in k_n, Y_0, and/or Y_1. Taking derivatives of θ^* with respect to k_n, Y_0, and Y_1, I find that, given the assumptions that some portion of first- and second-period investments must be financed by borrowing (i.e., $I_0 > k_n$ and $I_1 > Y_0 + k_n$) and that investment returns are non-negative (i.e., $Y_0 > I_0$, $Y_1 > I_1$), then $\partial\theta^*/\partial Y_0$, $\partial\theta^*/\partial Y_1$, and $\partial\theta^*/\partial k_n$ are all strictly negative. A decline in k_n, Y_0, and/or Y_1 will thus correspond to an increase in minimum credit quality, θ^*.

Proposition 2 *After an adverse aggregate shock, the rate of interest on loans will decline if the market power of the lender is sufficiently large.*

Proof It is straightforward to show that, given the assumption that some portion of first-period investment must be financed by borrowing (i.e., $I_0 > k_n$), $\partial r^*/\partial Y_0$ and $\partial r^*/\partial Y_1$ are strictly positive, meaning a decline in first- and/or second-period investment returns, Y_0 and Y_1, will lower the optimal rate of interest. However, the optimal interest rate will only decrease with a decline in initial capital if the value of repeat business with good entrepreneurs is sufficiently high; otherwise, a decline in k_n will increase r^*. That is, $\partial r^*/\partial k_n > 0$ if and only if $R > \dfrac{I_0 + I_1 - Y_0 - Y_1}{(1-\theta)(I_0 + Y_0 - I_1)}$. This implies that the greater the MFI's market power—and thus the higher the second-period rents the MFI can earn from repeat business with good entrepreneurs—the more likely an adverse shock to initial

[3] See Appendix 4.1 for derivation of the following propositions. As demonstrated in Chap. 2 and Chap. 3, farms in severely infected districts with a Loan Fund relatively increased investments in alternative agricultural activities during the famine, particularly through the acquisition of traditional buffer stocks of poultry and swine, but also through conversion of land to other tillage crops. Most of these investments consisted of substitutions away from the potato, a highly non-tradeable good, to more tradeable goods for export. The evidence therefore strongly suggests that returns to alternative agricultural investments remained large and positive throughout the famine.

wealth may lower interest rates, as greater market power and lower starting capital mean the lender can earn more on larger loans in the second period. Since $\partial r^*/\partial Y_0$ and $\partial r^*/\partial Y_1$ are strictly positive but the sign of $\partial r^*/\partial k_n$ is ambiguous, an adverse income shock may raise, lower, or have no effect on interest rates, depending on the market power of the lender and the relative magnitudes of the shocks to k_n, Y_0, and/or Y_1.

Proposition 3 *After an adverse aggregate shock, loan demand will increase.*

Proof Assuming the magnitude of the shock to investment returns is not so large as to render projects unprofitable (i.e., $Y_0 - \Delta Y_0 > I_0$ and $Y_1 - \Delta Y_1 > I_1$), the adverse shock to household capital, Δk_n, and first-period revenue, ΔY_0, will have the effect of shifting the distribution function $G(k)$ leftward, such that for more entrepreneurs will it now hold that $\Delta k_n < I_0$ and $Y_0 + k_n < I_1$. Thus, not only will households that already required external financing now have need of additional credit, but also households that previously were able to entirely self-finance investment projects will now require external financing.[4] The net effect on average loan size is therefore ambiguous, since while existing borrowers will require larger loan amounts, the entrance of new borrowers previously able to finance investment projects from their own funds may lower the average loan size.

An additional channel through which an adverse aggregate shock might affect lending is a decline in MFI liquidity. While Piesse (1841) and McLaughlin (2009) note that the majority of Loan Fund depositors held deposits of £10 or more, and thus were less likely to be directly affected by the failure of the potato crop, McLaughlin (2009) also finds that many depositors withdrew their savings during the famine out of concern that rising default rates would threaten the solvency of particular Loan Funds. The general equilibrium effects of the famine on the deposit baseof Irish financial institutions were also significant, as lower aggregate demand and the need for higher nutritional efficiency wages for farm laborers imposed severe negative income shocks on middle- and upper-income

[4] Berg and Schrader (2012) find an increase in MFI loan demand following volcanic eruptions in Ecuador.

depositors, forcing many to withdraw funds from savings institutions. Moreover, donations to funds in worse affected districts declined by an average of 23% more during the famine than donations to funds in less affected districts. The consequently higher reserve requirements to meet potential liquidity shortfalls would have effectively raised the cost of capital for affected funds. If we therefore allow the risk-neutral risk-adjusted rate of interest charged to borrowers to include a liquidity discount, λ, we find that $\partial r^*/\partial\lambda < 0$ and $\partial\theta^*/\partial\lambda > 0$, meaning an increase in the cost of capital will raise the minimum credit quality, θ^*, and lower the optimal interest rate, r^*. The theoretical model outlined here therefore strongly predicts that an adverse aggregate shock will result in tighter credit standards, with higher-quality repeat borrowers able to borrow at lower rates of interest.

4.2 Empirical Framework

Following Hornbeck (2012) and Goodspeed (2016a, b), the empirical analysis is based on estimating average changes in the probability of Loan Fund survival and Loan Fund activity, first, for funds operating in baronies more severely infected by blight relative to funds in less severely infected baronies, and, second, for funds in more severely infected baronies with different pre-famine management and financial metrics, in the same county and Poor Law Union and with similar pre-famine characteristics.

I define fund survival, S_{it}, for fund i in year t as a binary variable assuming a value of 1 if fund i extended loans in both 1844, the last year before the arrival of blight, and in year t; and 0 if fund i was active in 1844 but not in year t.[5] To estimate average changes in the probability of fund survival by blight severity, each survival outcome S_{it} for fund i in year t is regressed on binary variables for medium- and high-blight infection at the baronial level ($\boldsymbol{B}_b^{med}$ and $\boldsymbol{B}_b^{high}$), pre-famine baronial characteristics ($\boldsymbol{X}_b$), the number

[5] Funds which did not submit reports in any given year are noted in the annual reports of the Loan Fund Board as having failed to report. When a fund failed to report by the filing deadline in a given year, the Board substituted the preceding year's figures. In my analysis, I accept the Board's figures for any one year, but categorize funds which failed to report for two or more successive years, and funds reporting the same figures for more than two successive years, as having failed. For the period of analysis, there are three such cases.

of Loan Funds operating in the same barony b as fund i in year t (N_{bt}), a binary variable for whether fund i pooled accounts with another society in year t (ϕ_{it}),[6] barony (α_b) fixed effects, and an error term (ε_{it}):

$$S_{it} = \beta_{1t} B_b^{med} + \beta_{2t} B_b^{high} + \boldsymbol{X}_b' \delta + N_{bt} + \phi_{it} + \alpha_b + \varepsilon_{it} \quad (4.1)$$

To evaluate the effect of blight severity on average changes in Loan Fund lending, number of loans, capital, number of depositors, average interest rate, ratio of fines to total lending, and bad debts, each outcome, Y_{it}, for fund i in year t is differenced from its 1841–44 average, Y_{ipre}. Differencing allows us to control for unobservable fund characteristics that vary across funds but are fixed over time. This difference is then regressed on binary variables for medium- and high-blight infection at the baronial level (B_b^{med} and B_b^{high}), pre-famine baronial characteristics ($\boldsymbol{X}_b$), the number of funds operating in the same barony b as fund i in year t (N_{bt}), a binary variable for whether fund i pooled accounts with another society in year t (ϕ_{it}), barony (α_b) fixed effects, and an error term (ε_{it}):

$$Y_{it} - Y_{ipre} = \beta_{1t} B_b^{med} + \beta_{2t} B_b^{high} + \boldsymbol{X}_b' \delta + \gamma_t N_{bt} + \phi_{it} + \alpha_b + \varepsilon_{it} \quad (4.2)$$

In order to evaluate the effects of particular fund management practices, in Sect. 4.3.2, I estimate an expanded Eq. 4.1, adding a vector of average annual pre-famine Loan Fund financial metrics, L_i.[7] Further, each of these metrics is fully interacted with medium and high blight:

[6] The annual reports of the Loan Fund Board note that some funds operated so intimately with associated Mont-de-Piétés that their accounts were reported jointly. In all regressions, I therefore include as an independent binary variable whether or not a given fund operated jointly with another Loan Fund, Mont-de-Piété, or other credit institution in a given year, as noted in the Loan Fund Board reports. I include this variable to help attenuate the potential positive bias of the omitted factor that most Loan Funds were unable to smooth shocks on either the asset or liabilities side of their balance sheets.

[7] Included metrics are average annual pre-famine leverage ratio (total lending divided by capital), average annual pre-famine salary per employee (total wage bill divided by number of employees), average annual pre-famine gross profit margin per loan (gross revenue minus total expenses divided by number of loans), average annual pre-famine non-staff, non-capital expense ratio (total expenses, less wages and capital costs divided by total lending), average annual pre-famine loan size, average

$$S_{it} = \beta_{1t} B_b^{med} + \beta_{2t} B_b^{high} + \beta_{3t} L_i + \beta_{4t} L_i \times B_b^{med} + \beta_{5t} L_i \times B_b^{high} + \boldsymbol{X}_b' \delta + N_{bt} + \phi_{it} + \alpha_b + \varepsilon_{it} \quad (4.3)$$

Finally, to further examine the mechanisms through which various fund metrics that were associated with higher/lower predicted probabilities of survival where blight infection was more severe may have affected institutional resilience, I estimate their effects on average changes in the mean annual number of loans, loan size, interest rate, ratio of fines to total lending, bad debts, expense ratio, and gross profit margin per loan during the famine. Each outcome, Y_{ifam}, for fund i, averaged over the duration of the famine, is differenced from its 1841–44 average, Y_{ipre}. This difference is then regressed on binary variables for medium- and high-blight infection at the baronial level (B_b^{med} and B_b^{high}), a vector of the relevant average annual pre-famine Loan Fund financial metrics (L_i), pre-famine baronial characteristics ($\boldsymbol{X}_b$), the average number of Loan Funds operating in the same barony b as fund i during the famine (N_b), a binary variable for whether fund i pooled accounts with another society during the famine (ϕ_i), barony (α_b) fixed effects, and an error term (ε_i). Each of the included fund metrics is also interacted with medium and high blight at the baronial level, to allow fund financials to have had different effects where blight infection was more severe:

$$Y_{ifam} - Y_{ipre} = \beta_1 B_b^{med} + \beta_2 B_b^{high} + \beta_3 L_i + \beta_4 L_i \times B_b^{med} + \beta_5 L_i \times B_b^{high} + \boldsymbol{X}_b' \delta + N_b + \phi_i + \alpha_b + \varepsilon_i \quad (4.4)$$

annual pre-famine cost of capital (interest payments divided by capital), average annual pre-famine fines ratio (total fines divided by total lending), average annual pre-famine volume of bad debts, average annual pre-famine number of loans, and whether the manager was a minister. I also include as a three-way interaction medium (and high) blight multiplied by average salary by profit margin. This allows for the fact that funds operating in locales with similar levels of blight infection and pre-famine profit margins may have experienced systematically different survival probabilities and balance sheet changes where higher margins were associated with higher salaries. In other words, the three-way interaction allows for funds paying higher average salaries to experience differential effects of blight if those salaries were associated with higher profitability (consistent with an efficiency wages interpretation of higher salaries) versus lower profitability (consistent with a corruption interpretation, in which profits are absorbed by higher salaries).

In addition, for average gross profit margin per loan, I also estimate the effects of pre-famine metrics on non-differenced famine levels, Y_{ifam}.

For non-fixed but observable fund characteristics, the included controls in Eqs. (4.1) through (4.4) are baronial valuations completed by 1845, area in 1841, adult male and female literacy rates (reading, writing, or both) in 1841, the potato crop share of total acreage under tillage in 1844, the fraction of housing stock rated fourth class in the 1841 census, pre-1845 valuation per capita, population density in 1841, the 1841 share of families at the county level drawing income from agricultural work, and the county-level number of males and females employed in the cloth industry in 1841.[8] In the absence of income or wealth statistics, these variables are included as proxies for local economic development and poverty. Acreage under potato crop as a share of total tillage acreage in 1844 is included to allow funds operating in locales similarly impacted by blight but with different pre-famine levels of potato dependence to experience systematically different changes after 1845. Additionally, blight severity is interacted with fourth-class housing share, to allow for blight to have had more or less of an effect on Loan Fund outcomes where initial poverty was greater.[9]

Along these observable dimensions, in Eqs. (4.1) and (4.2), funds differentially afflicted by blight are allowed to experience systematically different changes after 1845. The identification assumption is that, controlling for barony fixed effects, funds in baronies with different blight infection rates but similar pre-famine characteristics would have had the same survival probabilities after 1845 if not for blight. In Eqs. (4.3) and (4.4), funds with different pre-famine financial metrics are likewise allowed to experience systematically different survival probabilities and changes in lending activity and balance sheet metrics after 1845. The identification assumption is that, controlling for barony fixed effects, funds in baronies with similar pre-famine characteristics and the same

[8] In the 1841 *Census of Ireland*, fourth-class houses are defined as "all mud cabins having only one room."

[9] Though the main sample of blight severity includes 255 observations, the number of observations for all regressions is less than 255. This owes to the fact that not all baronies in my blight sample had a Loan Fund and because funds missing pre-famine observations of included outcome and control variables are automatically excluded.

level of blight infection would have had the same survival probabilities and changes in lending activity after 1845 if not for differences in pre-famine management and financials.

The coefficient β_{5t} in Eq. (4.3) reports whether funds in baronies suffering from severe blight infection in 1845 and 1846 were more or less likely to survive than funds in baronies with moderate blight infection if there was a history of more leverage, higher salaries, etc., compared to the difference in survival probabilities between funds in high-infection and low-infection baronies when there was less leverage, lower salaries, etc., controlling for all other pre-famine baronial and fund characteristics and barony fixed effects. This allows for pre-famine fund management and financials to have had more or less of an effect on the probability of institutional survival where blight infection was greater. Similarly, the coefficient β_5 in Eq. (4.4) reports whether funds in baronies suffering from severe blight infection in 1845 and 1846 experienced differential changes in average lending and balance sheet metrics during the famine if they had been more highly levered, been paying higher salaries, etc., versus if they had been less levered, been paying lower salaries, etc. This allows for pre-famine fund management and financials to have had more or less of an effect on average changes in lending activity and balance sheet metrics where blight infection was greater. Because it is a strong identifying assumption that average pre-famine financial metrics were not correlated with other non-fixed baronial characteristics that may have been correlated with differential fund performance during the famine, as a robustness check, in Sect. 4.4.3, I also regress these fund variables on available pre-famine baronial-level social and economic indicators to test for systematic differences in pre-famine financials.

Several additional estimation details are worth noting. First, Eqs. (4.1) and (4.3) are estimated using a linear probability model (LPM).[10] To correct

[10] The linear probability model permits an easier interpretation of estimated coefficients than in alternative specifications. In addition, coefficients in a linear model directly measure marginal effects for the probability that an outcome occurs. The simpler specification is also employed because with few time points (the famine years) and long-duration intervals, a robust method like OLS is preferable to iterative procedures such as logistic regression or instantaneous hazard models. However, since F is a binary discrete variable, the variance is not homoscedastic, but varies with the values of the independent variables. Formally, if ρ_i is the probability of failure and $\boldsymbol{X}_i$ a vector of independent variables ($\rho_i = \Pr(F_i = 1 | \boldsymbol{X}_i)$), then the LPM is $\rho_i(\boldsymbol{X}) = \beta \boldsymbol{X}_i + \varepsilon_i$. As F_i is a binary discrete

for heteroskedasticity, I therefore take robust standard errors (Angrist and Pischke 2008). Second, standard errors are clustered at the fund level to adjust for within-fund correlation over time. Third, outcome years analyzed are selected so as to estimate average effects during and immediately after the famine. Fourth, available historical data does not allow me to identify the extent to which observed average changes in lending and interest rates are due to supply- or demand-side factors. However, since Dercon (2002), Becchetti and Castriota (2008), Berg and Schrader (2012), Goodspeed (2016a), Chap. 3 of this text have demonstrated that demand for microfinance credit generally increases in the event of an adverse environmental shock, with Goodspeed (2016a) and Chap. 3 of this text finding a particularly strong effect of access to microfinance on accumulations of buffer livestock during the famine, observed average changes reported here should be interpreted as providing a lower bound for the magnitude of the effect of natural disasters on MFI credit supply.

4.3 Results

4.3.1 Estimated Effects of Blight Severity

Results of estimating Eqs. (4.1) and (4.2) are reported in Table 4.1. Column (1) reports LPM-estimated coefficients for the effect of blight severity on the probability of fund survival through the indicated year. Results show that funds in baronies experiencing severe blight infection in 1845 and 1846 had a 24.1-percentage point lower predicted probability of surviving the first three years of the famine. By 1852, the predicted probability of survival was a large and statistically significant 34.8 percentage points lower for funds located in baronies suffering high-blight infection in 1845–46, compared to funds located in low-infection baronies.

Estimated coefficients reported in columns (2)–(8) of Table 4.1 show that blight also had a significant effect on Loan Fund balance sheets. By

variable, ε_i can only take two values, $\varepsilon_i = (1-\beta \boldsymbol{X}_i)|F_i = 1$ and $\varepsilon_i = -\beta \boldsymbol{X}_i|F_i = 0$. By definition, since $E(\varepsilon_i)|\boldsymbol{X}_i = 0$, we have $\sigma_i^2 = E[(\varepsilon_i - E(\varepsilon_i))^2|\boldsymbol{X}_i] = E(\varepsilon_i^2) = \rho_i(1-\beta \boldsymbol{X}_i)^2 + (1-\rho_i)(-\beta \boldsymbol{X}_i)^2 = \beta \boldsymbol{X}_i(1-\beta \boldsymbol{X}_i)^2$, which varies with i, thus establishing the heteroscedasticity of the residuals ε_i. To correct for this consequent heteroscedasticity, I compute robust standard errors.

Table 4.1 Estimated Loan Fund survival probability and changes in financial metrics, high versus low blight

	Fund survival	Lending	Loans	Capital	Depositors	Interest	Fines ratio	Bad debts
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1846	−0.103	−2243.144**	−373.686	−240.94	−2.274	−0.049	0.063	−19.596**
	(0.15)	(1097.99)	(331.37)	(309.85)	(2.08)	(0.04)	(0.06)	(8.93)
1847	−0.025	−4688.478**	−1102.733**	−715.435*	−3.659*	−0.025	−0.023	−20.654**
	(0.15)	(1843.06)	(533.36)	(400.07)	(2.20)	(0.02)	(0.03)	(10.39)
1848	−0.241*	−4522.917**	−1123.025**	−1170.667**	−11.805*	−0.089*	−0.071*	−25.658***
	(0.14)	(2034.86)	(552.31)	(520.53)	(6.40)	(0.05)	(0.04)	(9.55)
1852	−0.348**	−4873.925*	−1044.567*	−1226.031*	−16.093*	−0.057***	−0.059**	−23.704**
	(0.14)	(2767.47)	(608.80)	(634.19)	(9.33)	(0.02)	(0.03)	(11.51)
N	191	191	191	191	191	191	191	191
R2	0.190	0.169	0.183	0.182	0.136	0.219	0.114	0.186

Notes: Column (1) reports LPM estimates of Loan Fund survival by high- vs. low-blight severity (β_{2t}'s in Eq. (4.1) in the text). Columns (2)–(8) report estimated coefficients for differences in average changes in total lending, number of loans, capital, number of depositors, interest rate, ratio of fines to total lending, and bad debts by blight severity (see Eq. (4.2) in the text). Included control variables for all regressions are (at the baronial level) the share of 1841 housing stock rated fourth class; the 1844 potato crop share of total tillage acreage; male and female literacy rates in 1841; pre-famine valuation and valuation per capita, area, total population, and population density in 1841; and (at the county level) the fractions of families drawing a majority of income from agriculture and manufacturing and the county-level numbers of men and women engaged in the cloth industry. Blight severity is additionally interacted with fourth-class housing. Also included are the number of funds in the barony, a binary variable for whether the fund pooled accounts with another society, and barony fixed effects. Robust standard errors are reported in parentheses and clustered at the baronial level. ***p < 0.01, **p < 0.05, *p < 0.10

the third year of the blight, in 1847, funds located in severely infected baronies had reduced the total annual lending volume by £4688 more than funds in less infected baronies and extended 1103 fewer loans. On the liabilities side, by 1848, funds in severely infected baronies had lost £1171 more of their capital, relative to funds in low-infection baronies, and 12 more depositors. By the end of the famine, in 1852, relative to funds in moderately infected baronies, funds in severely infected baronies had reduced lending by £4874 and the number of loans by 1044 and had lost £1226 more of their capital and 16 more depositors.

Estimated coefficients reported in column (6) indicate that, for funds in severely affected baronies, average interest rates (including application and surety screening fees) on loans declined, relative to average interest rates on loans extended by funds in moderately affected baronies. By 1848, average annualized interest charged by funds in worse infected baronies was 890 basis points lower than average interest on loans extended by funds in low-infection baronies, with the relative differential persisting through 1852. Estimated coefficients reported in column (7) of Table 4.1 also show a relative decline in the ratio of delinquency fines to total lending by funds in high-blight baronies. By 1848, the ratio of fines to total lending was 710 basis points lower for funds in severely infected baronies than for funds in low-infection baronies. Results presented in column (8) reveal that the volume of bad debts also decreased relatively for funds in severely affected baronies during the famine; by 1848, funds in high-blight baronies had decreased the amount of bad debts on their books by £26, relative to funds in low-blight baronies.

These results suggest that in the short and medium runs, funds located in baronies experiencing greater blight infection responded primarily by balance sheet contraction. Moreover, the relative decline in bad debts and the ratio of fines to lending implies that funds in worse affected baronies significantly raised credit standards, while the observed relative decline in interest income indicates that funds in worse affected baronies were also collecting less in interest and application and surety screening fees as a percentage of lending, which suggests that borrowing costs for repeat and/or high-credit quality borrowers actually fell.

4.3.2 Estimated Effects of Fund Management

Results from estimating Eq. (4.3) are presented in Table 4.2. Each column in Panel A of Table 4.2 reports estimated β_{3t}'s, the main effect of the indicated pre-famine Loan Fund management or financial metric on the predicted probability of fund survival, while each column in Panel B reports estimated β_{5t}'s, the interaction effect of pre-famine Loan Fund metrics where blight infection was high (severe) on the predicted probability of fund survival. I report both main and interaction effects of Loan Fund management and financial metrics because results indicate that different pre-famine Loan Fund metrics had in some cases quite different effects on the probability of fund survival where blight infection was more severe.

Estimated coefficients reported in columns (1) through (3), Panels A and B, indicate that while higher pre-famine leverage ratios were generally associated with a higher predicted probability of surviving the first three years of the famine, greater leverage had a significant negative effect on the predicted probability of fund survival where blight infection was more severe. Estimated coefficients reported in column (3), Panels A and B, reveal that by 1848, the main effect of a 100% increase in the average pre-famine leverage ratio (e.g., from 4:1 to 5:1) was a non-statistically significant 9.9-percentage point higher predicted probability of institutional survival, whereas in baronies suffering from severe blight infection, a 100% increase in average pre-famine leverage was associated with a 19.3-percentage point lower predicted probability of survival.

Estimated coefficients reported in columns (1) through (3), Panel A, also reveal that the main effect of higher average staff salaries was a lower predicted probability of institutional survival during the famine, with a £1 increase in average employee salary lowering the predicted probability of survival by 1.4 percentage points through 1847. However, estimated coefficients reported in columns (2) and (3), Panel B, reveal that higher average salaries had a net positive effect on the probability of fund survival where blight infection was more severe; funds in severely infected baronies paying £1 more in average employee salaries before the famine had a net 0.2-percentage point greater probability of survival through

Table 4.2 Estimated Loan Fund survival probability by pre-famine metrics interacted with high blight

	1846	1847	1848	1852
	(1)	(2)	(3)	(4)
Panel A: Main effects				
Leverage ratio	0.092**	0.067	0.099	0.257***
	(0.05)	(0.05)	(0.08)	(0.09)
Ave salary	–0.009	–0.014*	–0.015*	–0.019*
	(0.01)	(0.01)	(0.01)	(0.01)
Profit margin per loan	–0.853	–0.186	1.086	–1.641
	(0.95)	(1.67)	(1.85)	(1.76)
Expense ratio	–12.638**	–9.491	0.044	–6.336
	(5.34)	(6.02)	(7.53)	(7.05)
Manager a minister	–0.051	–0.039	–0.031	–0.189*
	(0.08)	(0.10)	(0.11)	(0.11)
Ave loan size	–0.062	–0.013	–0.032	–0.091**
	(0.04)	(0.06)	(0.07)	(0.05)
Fines ratio	–0.961	–1.024	–5.510*	0.963
	(2.36)	(2.79)	(3.31)	(3.41)
Bad debts	0.002	0.002	–0.002	–0.007
	(0.01)	(0.01)	(0.01)	(0.01)
Number of loans	0.066	0.041	–0.002	–0.006
	(0.08)	(0.10)	(0.13)	(0.13)
Cost of capital	–0.666	0.068	1.761	0.986
	(2.71)	(5.71)	(6.05)	(5.70)
Depositors	0.006*	0.006	0.007	0.013**
	(0.00)	(0.00)	(0.01)	(0.01)
Panel B: Interactive effects				
Leverage ratio	–0.004	–0.096	–0.193*	–0.317***
	(0.06)	(0.08)	(0.11)	(0.12)
Ave salary	0.007	0.016*	0.016*	0.029***
	(0.01)	(0.01)	(0.01)	(0.01)
Profit margin per loan	0.287	2.430	1.257	4.617**
	(1.09)	(1.76)	(2.19)	(2.08)
Expense ratio	11.883*	14.789*	2.478	12.452
	(6.22)	(7.90)	(10.54)	(9.98)
Manager a minister	0.056	–0.022	–0.116	0.120
	(0.09)	(0.15)	(0.17)	(0.16)
Ave loan size	0.034	0.047	0.077	0.155**
	(0.05)	(0.08)	(0.09)	(0.07)
Fines ratio	1.16	–0.073	4.022	–2.44
	(2.34)	(2.97)	(3.53)	(3.67)
Bad debts	–0.002	–0.002	0.005	0.008

(*continued*)

Table 4.2 (continued)

	1846	1847	1848	1852
	(1)	(2)	(3)	(4)
	(0.01)	(0.01)	(0.01)	(0.01)
Number of loans	–0.035	–0.097	–0.055	–0.076
	(0.10)	(0.13)	(0.16)	(0.17)
Cost of capital	–3.561	0.197	0.459	–2.612
	(3.93)	(7.00)	(7.80)	(7.46)
Depositors	–0.004	–0.004	–0.008	–0.018***
	(0.00)	(0.01)	(0.01)	(0.01)
N	191	191	191	191
R2	0.273	0.263	0.203	0.231

Notes: Columns (1) through (4) report LPM estimates of Loan Fund survival by pre-famine Loan Fund metrics, averaged over 1841–44. Each column in Panel A reports estimated main effects (β_{4t}'s of Eq. (4.3)), while each Panel B column reports estimated interaction effects (β_{5t}'s of Eq. (4.3)). Included control variables for all regressions are (at the baronial level) the share of 1841 housing stock rated fourth class; the 1844 potato crop share of total tillage acreage; male and female literacy rates in 1841; pre-famine valuation and valuation per capita, area, total population, and population density in 1841; and (at the county level) the fractions of families drawing a majority of income from agriculture and manufacturing and the county-level numbers of men and women engaged in the cloth industry. Blight severity is additionally interacted with fourth-class housing. Also included are the number of funds in the barony, a binary variable for whether the fund pooled accounts with another society, and barony fixed effects. Robust standard errors are reported in parentheses and clustered at the baronial level. ***p < 0.01, **p < 0.05, *p < 0.10

1847 than funds in severely infected baronies paying less. While higher salaries were therefore generally associated with a lower survival probability, in the presence of a major covariate shock, higher staff remuneration was associated with a higher probability of survival.

Pre-famine differences in fund scale, gross profit margin per loan, average loan size, fines ratio, cost of capital, bad debts, and whether or not the fund manager was a minister do not appear to have had differential effects on survivability during the first three, and most acute, years of famine.[11]

[11] Fund scale is proxied by the average annual number of loans extended. Fines ratio refers to the ratio of fines collected to total lending. Unfortunately, available data does not distinguish whether variation in the rate of pre-famine fine collection was due to differences in actual delinquency rates or rather to differences in the intensity of fine collection.

Average pre-famine expense ratios were generally a strong short-run predictor of institutional survivability—funds with a 1-percentage point higher expense ratio had a 12.638-percentage point lower probability of survival through 1846 than funds with a lower expense ratio—but differences in pre-famine expense ratios appear to have had no net differential effect on the predicted probability of fund survival where blight infection was severe.[12] Higher expense ratios may have been associated with a net positive effect on the predicted probability of survival through 1847 where blight infection was worse—funds in severely infected baronies with a 1-percentage point higher expense ratio had a 14.789-percentage point higher probability of survival through 1847 than funds in severely infected baronies with a lower expense ratio—though the estimated effect appears to have dissipated by 1848.

Estimated coefficients reported in column (4), Panels A and B, show the effects of pre-famine financials on the predicted probability of survival through the end of the famine in 1852. Results again indicate that management practices that were generally positively (negatively) associated with fund survival were in several instances negatively (positively) associated with survival in the presence of severe blight infection. While higher leverage generally had a positive effect on the predicted probability of survival through 1852—a 100% increase in average pre-famine leverage was generally associated with a 25.7-percentage point higher predicted probability of survival—for funds in severely infected baronies, the net effect of a 100% increase in leverage was a 6.0-percentage point lower predicted probability of survival. In contrast, whereas the main effect of higher average employee salaries before the arrival of blight was a lower predicted probability of survival through 1852, higher pre-famine salaries had a positive effect on the probability of institutional survival where blight infection was more severe. While the main effect of a £1 increase in average pre-famine staff salary was a 1.9-percentage point lower predicted probability of survival through 1852, funds in severely infected baronies paying £1 more in average employee salaries had a

[12] Expense ratio refers to the ratio of non-staff operating costs, excluding cost of capital, to total lending.

net 1-percentage point higher probability of survival through 1852 than funds in severely infected baronies paying £1 less.

The estimated coefficient reported in column (4), Panel A, also indicates that ministers were generally less competent fund managers. Funds with a minister as manager before the famine had an 18.9-percentage point lower probability of survival through 1852 than funds with a non-clergy manager. Having a minister as manager, however, appears to have had no additional statistically significant differential effect on the probability of survival where blight infection was severe, which suggests that while ministers were generally less competent fund managers, they were no more or less capable of handling a major adverse shock than non-clergy managers. Estimated coefficients reported in column (4), Panels A and B, also suggest that while larger loans were generally associated with a lower predicted probability of survival, where blight infection had been severe the net effect of a £1 increase in average pre-famine loan size was a 6.4-percentage point higher predicted probability of institutional survival through 1852.

Results presented in column (4), Panels A and B, indicate that while a larger depositor base was generally associated with a higher predicted probability of institutional survival through the end of the famine, the reverse was true where blight infection was more severe. While an additional depositor before the famine was generally associated with a 1.3-percentage point higher probability of survival through 1852, for funds located in severely infected baronies, one more depositor was associated with a net 0.50-percentage point lower predicted probability of institutional survival through 1852.

Estimated coefficients for the interaction effects of different pre-famine fund metrics and severe (high) blight infection on Loan Fund activity during the famine—β_5's in Eq. (4.4)—are presented in Table 4.3. Estimated coefficients reported in column (1) indicate that funds in severely affected baronies with higher pre-famine gross profit margins per loan, leverage ratios, expense ratios, and more depositors did not experience systematically different changes in the average annual number of loans extended during the famine. Funds in high-blight baronies that had been paying £1 more in average staff salaries before the famine, however, relatively reduced the average number of loans extended during the

Table 4.3 Estimated changes in Loan Fund activity by pre-famine metrics interacted with high blight

	Loans	Loan size	Interest rate	Fines ratio	Bad debts	Expense ratio	Margin per loan	Margin per loan (level)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Margin per loan	–26,211.072	–89.143**	–2.304**	–2.950***	–1089.684**	0.093	–0.848***	0.373
	(19,797.04)	(42.22)	(1.01)	(0.73)	(541.43)	(0.14)	(0.20)	(0.26)
Leverage ratio	–129.222	0.033	–0.017	–0.001	9.943*	0.001*	–0.001*	–0.003***
	(98.01)	(0.19)	(0.01)	(0.00)	(5.80)	(0.00)	(0.00)	(0.00)
Ave salary	–27.100***	–0.006	0.000	–0.001*	–0.195	0.000	0.000*	0.001**
	(10.31)	(0.01)	(0.00)	(0.00)	(0.37)	(0.00)	(0.00)	(0.00)
Expense ratio	–14,623.982	–107.290*	–2.538	–1.84	–1181.023	–2.739***	1.717***	1.319***
	(29,257.17)	(63.68)	(2.05)	(3.44)	(748.05)	(0.29)	(0.42)	(0.45)
Depositors	–5.804	0.033***	0.001	0.000*	–0.660*	0.000	0.000	0.000
	(7.81)	(0.01)	(0.00)	(0.00)	(0.36)	(0.00)	(0.00)	(0.00)
N	191	191	191	191	191	191	191	191
R2	0.313	0.283	0.386	0.307	0.341	0.22	0.521	0.365

Columns (1)–(7) report estimated coefficients (β_5's of Eq. (4.4) in the text) for differences in mean changes in the average annual number of loans, loan size, interest rate, ratio of fines to total lending, bad debts, expense ratio, and gross profit margin per loan during the famine by pre-famine average annual Loan Fund metrics interacted with high-blight severity. Column (8) reports estimated coefficients for differences in the average level of gross profit margin per loan during the famine by pre-famine average annual Loan Fund metrics interacted with high blight. Included control variables for all regressions are (at the baronial level) the share of 1841 housing stock rated fourth class; the 1844 potato crop share of total tillage acreage; male and female literacy rates in 1841; pre-famine valuation and valuation per capita, area, total population, and population density in 1841; and (at the county level) the fractions of families drawing a majority of income from agriculture and manufacturing and the county-level numbers of men and women engaged in the cloth industry. Blight severity is additionally interacted with fourth-class housing. Also included are the number of funds in the barony, a binary variable for whether the fund pooled accounts with another society, and barony fixed effects. Robust standard errors are reported in parentheses and clustered at the baronial level. ***p < 0.01, **p < 0.05, *p < 0.10

famine by an additional 27.100 loans per year. Estimated coefficients reported in column (2) reveal that while funds in worse affected baronies with higher pre-famine leverage ratios and average salaries did not experience differential changes in average loan size during the famine, funds in severely affected baronies with higher pre-famine gross margins and more depositors did. Specifically, funds in severely infected baronies with an average pre-famine gross margin per loan higher by 100 basis points relatively reduced the average size of a loan during the famine years by £0.89 (17 s. 10d.), while funds in severely infected baronies with an additional depositor before the famine relatively increased average loan size during the famine by £0.03 (8d.).

Results presented in column (3) of Table 4.3 reveal that funds in severely infected baronies with an average pre-famine gross profit margin per loan higher by 100 basis points also relatively reduced the average rate of interest on loans, including application and surety fees, by an additional 230.4 basis points. Estimated coefficients reported in column (4) indicate that funds in severely infected baronies with higher pre-famine gross margins per loan and average salaries also relatively reduced the ratio of fines to total lending during the famine. For funds in high-blight baronies, a 100-basis point increase in average pre-famine gross profit margin was associated with a 295.0-basis point relative reduction in the average fines rate during the famine, while a £1 increase in average pre-famine employee salary was associated with a 10-basis point relative reduction in the average fines rate during the famine. Funds in high-blight baronies with more depositors, however, experienced relative increases in the ratio of fines to total lending during the famine; an additional pre-famine depositor was associated with a 4-basis point relative increase in the average fines rate during the famine.

Estimated coefficients reported in column (5) of Table 4.3 indicate that funds in severely infected baronies with higher margins on loans before the famine also relatively reduced the volume of outstanding debts. Funds in severely infected baronies with an average pre-famine gross profit margin per loan higher by 100 basis points relatively reduced their average annual volume of bad debts by £1089.68. In contrast, funds in high-blight baronies with more depositors experienced relative increases in the volume of bad debts during the famine; an additional depositor

before the famine was associated with a £0.66 (13s. 3 d.) relative increase in the average annual volume of bad debts during the famine.

Estimated coefficients reported in columns (6)–(8) of Table 4.3 suggest that different pre-famine fund financials had significant effects on differential changes in the cost of credit intermediation and profitability during the famine. Funds that had been more highly levered before the famine experienced a relative increase in the ratio of non-wage operating expenses to total lending during the famine, with a 100% increase in average pre-famine leverage associated with a 10-basis point relative increase in average expense ratio during the famine. In contrast, funds with higher non-wage expense ratios before the famine experienced a relative decline in average expense ratio during the famine. A 1-percentage point higher pre-famine expense ratio was associated with a 2.739-percentage point relative decrease in average expense ratio during the famine.

Both more levered funds, and more profitable funds, also experienced relative declines in the average gross profit margin per loan. A 100% increase in average pre-famine leverage was associated with a 10-basis point relative decline in the average margin per loan during the famine, while a 100-basis point increase in average pre-famine gross profit margin per loan was associated with an 84.8-basis point relative decline in average margin per loan. Funds with higher expense ratios before the famine, though, experienced relative increases in the average gross margin per loan during the famine. Funds with a 1-percentage point higher expense ratio before the famine experienced a 171.7-basis point relative increase in average margin per loan during the famine.

However, results reported in column (8) of Table 4.3 suggest that while funds with higher gross margins per loan before the famine experienced relative declines in the average margin per loan during the famine, there was no difference in their average, non-differenced level of gross profit margin per loan during the famine. Average margin per loan for funds that had been more highly levered, though, was lower during the famine. A 100% increase in average pre-famine leverage ratio was associated with a 30-basis point lower average gross margin per loan during the famine. In contrast, funds with higher average staff salaries and higher average non-wage expense ratios before the famine were relatively more profitable during the famine. A £1 increase in average pre-famine employee salary

and a 100-basis point increase in the average pre-famine expense ratio were associated with average gross profit margins per loan higher by 10 and 137.9 basis points, respectively, during the famine.

Overall, the results presented in Tables 4.2 and 4.3 suggest that differences in pre-famine fund management and financials played a significant role in determining the probability of surviving the adverse shock of the Great Famine. In particular, while funds with higher gross profit margins per loan and higher paid staff before the famine were more likely to survive the severe environmental shock, funds that had been more highly levered and funds with more depositors before the famine were less likely to survive the shock. Results further suggest that the primary mechanisms by which pre-famine financials influenced the probability of institutional survival were balance sheet contraction and an elevation of credit standards, and that funds with higher gross margins per loan and funds with more highly remunerated staff before the famine were more successful in effecting this retrenchment, while more levered funds and funds with more depositors were less successful.

Specifically, results reveal that though funds in worse affected districts with a higher average gross margin per loan before the famine did not reduce the average number of loans extended per year during the famine by any more or less than funds that had been less profitable on a per-unit basis, they did relatively reduce the average size of their loans. Moreover, during the famine, funds that had been more profitable on a per-unit basis relatively reduced the average interest rate charged on loans, the average ratio of delinquent fines to total lending, and the average volume of bad debts, implying a relative increase in average credit quality among approved borrowers. Similarly, funds in severely infected districts with more highly remunerated staff relatively reduced the average number of loans extended during the famine and experienced a relative decline in average fines ratios.

In contrast, funds in worse affected districts with more depositors before the famine experienced relative increases in average loan size, fines ratios, and bad debts during the famine, which indicates a relative decline in average credit quality compared to funds with fewer depositors. While funds in worse affected districts that had been more highly levered before the famine do not appear to have experienced systematically different

changes in lending or average credit quality during the famine, they did suffer a relative rise in the unit cost of credit intermediation and a relative decline in unit profitability. Funds in worse affected districts with higher average expense ratios before the famine, meanwhile, appear to have been able to relatively reduce their average expense ratios during the famine and thus experienced smaller relative declines in average gross profit margin per loan. However, funds in severely infected baronies with higher average pre-famine expense ratios had no higher probability of survival beyond 1847, which indicates that cost cutting was an effective adjustment mechanism only in the short run.

These findings suggest that Loan Funds that had been earning higher rents before the famine had more scope to contract credit and raise lending standards in response to an adverse aggregate shock, while still remaining profitable. Better compensated staffs similarly seem to have been more effective at restricting credit to higher-quality borrowers. In contrast, funds that had been relying more heavily on leverage before the famine appear to have been more severely affected by balance sheet contraction during the famine. Though more levered funds contracted lending by no more or less than less levered funds, they experienced relative increases in the unit cost of credit intermediation and relative decreases in average margin per loan, resulting in lower average margins on a per-unit basis during the famine.

4.3.3 Robustness Checks

Because it is a strong identifying assumption that average pre-famine gross profit margins, employee salaries, numbers of depositors, expense ratios, and leverage were not correlated with other non-fixed baronial characteristics that may have been correlated with differential fund performance during the famine, I also regress these fund variables on available pre-famine social and economic indicators. Results are reported in Table 4.4. Estimated coefficients reveal that differences in poverty levels (as proxied by the fraction of all occupied housing stock rated fourth class), potato dependence, wealth (as proxied by baronial valuation and valuation per capita), county-level fractions of households deriving the majority of

income from agriculture and manufacturing, and county-level numbers employed in the cloth industry do not explain observed differences in pre-famine gross profit margin per loan. Greater population density was associated with higher profit margins, though the estimated effect is small in absolute terms and significant only at the 10% level. While female literacy was associated with higher average pre-famine profit margins, male literacy was associated with lower margins. An additional Loan Fund in the same barony was associated with a 10-basis-point lower average pre-famine gross profit margin per loan, which suggests that higher margins may indeed have owed to greater market power. Again, however, the estimated effect is significant only at the 10% level, and the overall fit of the model is poor, with an R^2 of just 0.038.

Baronial valuation and the county-level number of females engaged in the cloth industry were associated with lower average pre-famine staff salaries, while fourth-class housing, potato dependence, literacy, county-level fractions of households deriving the majority of income from agriculture or manufacturing, the county-level number of males in the cloth industry, total population, and population density appear to have had no effect on differences in average pre-famine employee salaries. Funds in counties with a larger fraction of households deriving the majority of their income from manufacturing activity had more depositors, though county-level female employment in the cloth industry was associated with fewer depositors. Available pre-famine social and economic indicators appear to have had no effect on differences in average pre-famine fund expense ratios, as reported in column (4). Estimated coefficients reported in column (5) reveal that average pre-famine leverage ratios were actually lower where the share of housing rated fourth class was higher, but higher where overall population was greater. Other indicators appear to have been unassociated with differences in pre-famine leverage ratios.

In sum, results presented in Table 4.4 do not reveal any systematic variation in average pre-famine gross profit margins per loan, employee salaries, numbers of depositors, expense ratios, and leverage ratios that would be consistent with those variables being correlated with unobservable, non-fixed baronial characteristics that may in turn have been correlated with differential fund performance and balance sheet changes during the famine. Differences in average profit margins, which were positive predictors of

Table 4.4 Robustness checks

	Profit margin	Ave salary	Depositors	Expense ratio	Leverage
	(1)	(2)	(3)	(4)	(5)
% Fourth-class housing	0.004	–6.200	9.168	0.001	–1.664*
	(0.01)	(11.45)	(14.20)	(0.00)	(0.95)
Potato crop share	–0.005	–5.687	–9.548	0.001	–0.277
	(0.00)	(3.94)	(6.12)	(0.00)	(0.35)
Male literacy rate	–0.018*	–8.678	–30.968	0.002	–1.354
	(0.01)	(33.69)	(43.72)	(0.00)	(2.12)
Female literacy rate	0.012*	12.055	44.119	–0.001	–0.811
	(0.01)	(24.07)	(31.87)	(0.00)	(1.60)
% Families in agriculture	0.000	0.001	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
% Families in manufacturing	0.000	0.005	0.014***	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
% Males in cloth industry	0.000	0.000	–0.004	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
% Females in cloth industry	0.000	–0.002**	–0.003*	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Baronial valuation	0.000	–0.000**	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Valuation per capita	0.000	0.005	–0.338	0.000	0.003
	(0.00)	(0.21)	(0.24)	(0.00)	(0.01)
Population density	0.000*	0.230	0.167	0.000	0.006
	(0.00)	(0.46)	(0.76)	(0.00)	(0.06)
Total population	0.000	0.000	0.000	0.000	0.000**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Number of funds in barony	–0.001*	–0.956	0.581	0.000	–0.056
	(0.00)	(0.61)	(1.08)	(0.00)	(0.06)
N	191	191	191	191	191
R2	0.038	0.245	0.180	0.165	0.167

Notes: Each column reports estimated coefficients for average pre-famine levels of gross profit margin per loan, average staff salary, number of depositors, expense ratio, and leverage ratio by pre-famine baronial and county-level characteristics. Also included are baronial area and barony fixed effects. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

fund survival where blight infection was more severe, did not vary with differences in pre-famine levels of poverty or potato dependence. Average staff salaries, which were also positive predictors of fund survival where blight infection was more severe, were in fact lower where baronial valuation was higher, while the number of depositors, which was a negative predictor of survival where the environmental shock was worse, was actually greater in baronies with more families earning the majority of their income from manufacturing. Finally, average pre-famine leverage, which was also a negative predictor of survival where the severity of blight infection was worse, was in fact lower where the poverty level was higher.

Conclusion

I find that a large environmental shock can have significant adverse effects on MFI sustainability, resulting in lower institutional survival probabilities; large declines in lending, capital levels, and numbers of depositors; as well as substantial flight to quality in lending portfolios. During the Great Famine, borrowing costs for qualifying borrowers in worse affected districts therefore actually fell as funds in these districts contracted lending and significantly raised credit standards. I further find that pre-famine balance sheet data were important predictors of MFI survival during the famine, though certain metrics that were generally associated with higher (lower) survival probabilities were associated with lower (higher) survival probabilities where the magnitude of the environmental shock was greater. While greater leverage, lower average staff salaries, and more depositors were generally associated with higher predicted probabilities of institutional survival, the reverse was true where blight infection was more severe. Conversely, though funds with higher gross profit margins per loan before the famine were generally no more likely to succeed over the long run than less profitable funds, higher pre-famine margins were strong positive predictors of institutional survival where blight infection was worse.

Differences in pre-famine balance sheet metrics were also associated with differential institutional responses to the adverse shock. Relative to funds with lower average gross profit margins per loan before the famine,

funds in worse affected districts with higher pre-famine margins relatively reduced average loan size, interest rates, fines ratios, and bad debts during the famine, indicating a relative increase in average credit quality among approved borrowers. Funds in worse affected districts with more highly remunerated staff before the famine similarly relatively reduced their mean annual number of loans and fines ratios during the famine. However, though funds with higher pre-famine margins experienced relative declines in average margin per loan, there was no relative difference in their average, non-differenced level of profit margin per loan during the famine. In contrast, funds in severely infected districts with more depositors before the famine experienced relative increases in average loan size, fines ratios, and bad debts during the famine, while funds in worse affected districts that had been more highly levered before the famine experienced a relative rise in the average unit cost of credit intermediation and relative decline in profitability, resulting in a lower average gross profit margin per loan during the famine.

Results presented in this chapter therefore not only reaffirm the tension between sustainability and outreach in microfinance, but also reveals that optimal MFI lending models under ordinary circumstances may impede adjustment to a major aggregate shock. Specifically, results show that MFI sustainability in the face of a major spatially correlated shock depends critically on an ability to rapidly scale down lending, reduce average loan size, and significantly raise lending standards, and therefore that though microfinance may mitigate the effects of such shocks on borrowers of higher credit quality, it is not a viable mitigant for more vulnerable, marginal borrowers. This is consistent with the results presented in Chap. 3, above, in which I find that while access to Loan Fund credit had significant effects on relative accumulations of buffer livestock during the Great Famine by midsized farms of 5–15 acres, it had limited effects on relative changes in livestock holdings by farms of fewer than 5 acres.

Moreover, whereas a broader depositor base was ordinarily advantageous to institutional sustainability, the additional liability of more depositors appears to have limited funds' capacity to contract lending portfolios and raise average credit standards in response to adverse shock. Similarly, though greater leverage was generally a strong positive predictor of long-run MFI survival, where the magnitude of the environmental

shock was greater, funds that had been more highly levered were less able to effect balance sheet contraction while remaining profitable. In contrast, Loan Funds that had been earning higher rents before the famine appear to have had more scope to contract lending and raise credit standards while still remaining profitable. Meanwhile, higher paid staff, though ordinarily a long-run institutional liability, were more effective in restricting credit to higher-quality borrowers in response to worse blight infection.

The Great Famine of Ireland was a rare event that allows for an analysis of differential MFI outcomes and adjustment strategies to a major aggregate shock, over both the short and long runs. Further research is needed, however, to better understand the causes of variation in pre-famine MFI balance sheets and to evaluate the potential private and social welfare costs under ordinary conditions of greater institutional resilience to rare adverse environmental events.

Appendix 4.1

Taking derivatives of θ^* with respect to k_n, Y_0, and Y_1 yields:

$$\frac{\partial \theta^*}{\partial Y_0} = \frac{R\left(I_0 + k_n - Y_1\right) - \left(1+r\right)\left(I_0 - k_n\right)}{\left[\left(1+r\right)\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right)\right]^2}$$

$$\frac{\partial \theta^*}{\partial Y_1} = \frac{-1}{\left(1+r\right)\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right)}$$

$$\frac{\partial \theta^*}{\partial k_n} = \frac{\left(1+r+R\right)\left(I_0 + I_1 - Y_0 - Y_1\right)}{\left[\left(1+r\right)\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right)\right]^2}$$

Assuming some portion of first- and second-period investment must be financed by borrowing (i.e., $I_0 > k_n$ and $I_1 > k_n + Y_0$) and that investment returns are nonnegative (i.e., $Y_0 > I_0$, $Y_1 > I_1$), these are all strictly negative.

Taking derivatives of r^* with respect to k_n, Y_0, and Y_1 yields:

$$\frac{\partial r^*}{\partial Y_0} = \frac{1 + R - \theta R}{(1-\theta)(I_0 - k_n)}$$

$$\frac{\partial r^*}{\partial Y_1} = \frac{1}{(1-\theta)(I_0 - k_n)}$$

$$\frac{\partial r^*}{\partial k_n} = \frac{(1-\theta)R(I_0 + Y_0 - I_1) + Y_0 + Y_1 - I_0 - I_1}{(1-\theta)(I_0 - k_n)^2}$$

Again with the assumption that some portion of first-period investment must be financed by borrowing ($I_0 > k_n$), $\partial r^*/\partial Y_0$ and $\partial r^*/\partial Y_1$ are strictly positive. Since $(1-\theta)(I_0 - k_n)^2$ is always positive, the sign of $\partial r^*/\partial k_n$ is determined by the numerator. If $R > \frac{I_0 + I_1 - Y_0 - Y_1}{(1-\theta)(I_0 + Y_0 - I_1)}$, the numerator of $\partial r^*/\partial k_n$ is positive, meaning r^* is increasing in k_n. But if , then r^* is decreasing in k_n (i.e., $\partial r^*/\partial k_n < 0$).

If we then allow for the lender's cost of funds to vary, on account of higher liquidity requirements, the risk-neutral risk-adjusted rate on loans must therefore exceed its liquidity discount, λ. The lending constraint thus becomes

$$\theta(r - \lambda)(I_0 - k_n) + \theta(R - \lambda)(I_1 - k_n - Y_0) - (1-\theta)(I_0 - k_n) \geq 0$$

Solving for r^* and θ^* and taking derivatives with respect to λ, we find that

$$\frac{\partial r^*}{\partial \lambda} = \frac{\theta\left[(I_0 - k_n) + (I_1 - k_n - Y_0)\right]}{-(1-\theta)(I_0 - k_n)}$$

$$\frac{\partial \theta^*}{\partial \lambda} = \frac{\left[\left(I_0 - k_n\right) + \left(I_1 - k_n - Y_0\right)\right]\left[\left(1+r\right)\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right) + I_0 + I_1 - Y_0 - Y_1\right]}{\left[\left(1+r-\lambda\right)\left(I_0 - k_n\right) + \left(R-\lambda\right)\left(I_1 - k_n - Y_0\right)\right]^2}$$

Again assuming some portion of first- and second-period investment must be financed by borrowing (i.e., $I_0 > k_n$ and $I_1 > k_n + Y_0$), $\partial r^*/\partial \lambda$ is strictly negative. Since the denominator of $\partial \theta^*/\partial \lambda$ is always positive, the sign is determined by the numerator. Since $I_0 > k_n$ and $I_1 > k_n + Y_0$, the numerator will be positive if

$$Y_0 + Y_1 - \left(I_0 - k_n\right) > I_0 + I_1 + r\left(I_0 - k_n\right) + R\left(I_1 - k_n - Y_0\right)$$

Provided the shock to Y_0 and Y_1 not so large and negative as to render projects unprofitable, this inequality will hold, as otherwise households would not borrow.

5

Was Malthus Right?

> Although it is quite certain that the population of Ireland cannot continue permanently to increase at its present rate, yet it is certain that it will not *suddenly* come to a stop. Mr Newenham, assuming that it will go on for some time, at least, as it has done of late years, supposes that the country will contain 8,413,224 inhabitant in 1837; and enters into an elaborate calculation to show that it is fully capable of maintaining such a number. Knowing the uncertainty of all particular estimates of future population, we shall not give our sanction to the present, though it is certainly not impossible, nor even very improbably; and we feel confident, that a much greater population might in time be supported in that country if potatoes continue to be its staple food—Thomas Malthus, "Newenham and Others on the State of Ireland" (1808)

Building on the theoretical framework and empirical approach of Chaps. 2 and 3, in this chapter, I examine the role of traditional Malthusian variables in facilitating or hindering non-demographic agricultural adjustment to the shock of the famine, asking how relative marginal adjustments differed where demographic pressure, potato dependence, and initial poverty were more acute. The empirical analysis is therefore based on estimating average relative changes for more severely infected

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baronies with higher literacy, potato dependency, population density, valuation, and share of housing rated fourth class, versus average relative changes in worse affected districts with lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class, in the same county and PLU and with similar pre-famine characteristics.

The results presented here are generally inconsistent with a predominantly Malthusian account of the Irish Famine. That is, controlling for the severity of blight infection, access to microfinance credit, regional-time fixed effects, and spatial fixed effects, while higher adult literacy was associated with smaller relative population declines in worse affected districts, other traditional "Malthusian" variables do not appear to have been associated with differential demographic changes in worse affected districts, relative to less severely affected districts. Specifically, the cumulative population decline, relative to low-blight baronies, was still statistically no different in high- and medium-blight baronies with higher pre-famine population density, potato dependence, baronial valuations, and fourth-class housing stock versus high- and medium-blight baronies with lower pre-famine population density, potato dependence, baronial valuations, and fourth-class housing stock.

Results do, though, suggest that variation in pre-famine Malthusian pressures was associated with significant differential adjustments in land use and livestock acquisition and disposal, particularly over the medium to long runs in worse affected districts, relative to less affected districts. While greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were associated, in the short run, with greater acreage allocation toward the potato in worse affected districts, over the medium and long runs, worse affected districts with higher pre-famine potato dependence and fourth-class housing substituted crop acreage away from potato cultivation. Specifically, after the first year of blight, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively increased the fraction of tillage acreage allocated to the potato crop by 0.014 and 0.017 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation. By 1856, however, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively

reduced the fraction of tillage acreage allocated to the potato crop by 0.038 percentage points more than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation.

Similarly, after the first year of blight, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively increased the fraction of tillage acreage allocated to the potato crop by 0.007 and 0.006 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing. By 1856, however, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively reduced the fraction of tillage acreage allocated to the potato crop by 0.011 and 0.014 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Parallel to adjustments in crop acreage allocation, greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were also associated with differential changes in livestock assets among farms under 15 acres in worse affected districts. In the short through medium runs, farms under 15 acres in worse affected districts with higher pre-famine potato dependence and fourth-class housing stock, relative to equivalently sized farms in low-blight districts, increased stocks of buffer livestock holdings of chickens and pigs, compared to farms under 15 acres in worse affected districts with lower potato dependence and fourth-class housing stock. These relative accumulations, however, dissipated over the very long run. Greater pre-famine potato dependence and fourth-class housing stock were, moreover, associated with greater short-run liquidations of grazing livestock assets by farms under 15 acres in worse affected districts. Higher pre-famine population density and valuations, meanwhile, were associated with greater long-run relative accumulations of buffer livestock by farms under 15 acres in worse affected districts, in tandem with no long-run relative reduction in acreage allocation to the potato in more demographically dense districts and, indeed, a long-run relative reallocation toward the potato crop in districts with higher pre-famine valuations.

This chapter is structured so as to analyze in turn the effects of the various available pre-famine district characteristics on subsequent adjustment where blight infection was more severe. After elaborating the empirical framework in Sects. 5.1, 5.2.1, 5.2.2, 5.2.3, 5.2.4, and 5.2.5 report the results of estimating coefficients for pre-famine literacy, population density, potato dependence, valuation, and fourth-class housing concentration, respectively. Section 5.3 concludes.

5.1 Empirical Approach

Analogous to the empirical approach employed in Chap. 3, the empirical strategy here is based on estimating average changes in worse affected districts with higher literacy, potato dependency, population density, valuation, and share of housing rated fourth class, relative to less affected districts with higher literacy, potato dependency, population density, valuation, and share of housing rated fourth class, versus average changes in worse affected districts with lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class, relative to less affected districts with lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class.

Estimates are thus obtained by regressing each differenced outcome in barony b and year t on binary variables for medium- and high-blight severity (B_b^{med} and B_b^{high}), a binary variable for Loan Fund lending at some point during 1845 to 1850 (L_b), the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine ($BORD_b$), categorical variables for county (C_t) and PLU (PLU_t), and an error term (ε_{bt}). Loan Fund presence during the famine is again interacted with blight severity and lags of baronial outcomes (y_{bt-n})[1]: In addition, pre-famine adult literacy (reading, writing, or both; x_{1b}), potato dependency (acreage under potato crop as a share of total tillage acreage in 1844; x_{2b}), population density (x_{3b}), valuation(x_{4b}), and share of housing rated fourth class (x_{5b}) are likewise fully interacted with blight severity.

[1] The lags of baronial outcomes are for available pre-famine survey years excluding the immediately preceding survey year, Y_{bpre}.

$$Y_{bt} - Y_{bpre} = \beta_{1t} B_b^{med} + \beta_{2t} B_b^{high} + \beta_{3t} L_b + \beta_{4t} L_b \times B_b^{med} + \beta_{4t} L_b \times B_b^{high} + \gamma_{1t} y_{bt-n} + \gamma_{2t} L_b \times y_{bt-n} + BORD_b + \varphi_{1mt} x_{mb} + \varphi_{2mt} x_{mb} \times B_b^{med} + \varphi_{3mt} x_{mb} \times B_b^{high} + C_t + PLU_t + \varepsilon_{bt} \quad (5.1)$$

Since farm size data before 1845 and crop data from 1847–51 and after 1871 are not available at the baronial level, I again estimate changes at the PLU level for average changes in crop acreage allocation and farm size. Modifying Eq. (5.1), each outcome, Y_{ut}, in PLU u and year t is differenced from its pre-famine value, Y_{upre}, and the difference regressed on blight severity ($B_b^{med-high}$), a binary variable for Loan Fund presence during any one of the preceding famine years (L_u), the fraction of total PLU border length shared with other PLUs with at least one Loan Fund during the famine ($BORD_u$), a categorical variable for county (C_t), and an error term (ε_{ut}). Loan Fund presence is again interacted with blight severity and with lags of PLU outcomes (y_{u-n}). In addition, pre-famine potato dependency (x_{1u}), population density (x_{2u}), and valuation (x_{3u}) are likewise fully interacted with blight severity.[2]

$$Y_{ut} - Y_{upre} = \beta_{1t} B_u^{med-high} + \beta_{2t} L_u + \beta_{3t} L_u \times B_u^{med-high} + \gamma_{1t} y_{ut-n} + \gamma_{2t} L_u \times y_{ut-n} + BORD_u + \varphi_{1mt} x_{mu} + \varphi_{2mt} x_{mu} \times B_u^{med-high} + C_t + \varepsilon_{ut} \quad (5.2)$$

Differencing allows us to control for unobservable baronial or PLU characteristics that vary across districts but are fixed over time, while county and PLU categorical variables allow us to control for unobservable variables that vary by year but are constant across higher-level administrative units. In the absence of income or wealth statistics, including pre-famine adult literacy, potato dependency, population density,

[2] Unfortunately, literacy and fourth-class housing statistics are not available at the observational level of PLU.

valuation, and share of housing rated fourth class as independent variables allow us to control for the main effects of development and poverty. Acreage under potato crop as a share of total tillage acreage in 1844 also allows baronies similarly impacted by blight but with different pre-famine levels of potato dependence to experience systematically different changes after 1845.

Each regression furthermore includes the relevant outcome variable in the most proximate pre-famine year and all available pre-famine periods to control for possible pre-trends.[3] Loan Fund lending is interacted with lagged outcomes to allow for the possibility that Loan Fund activity may have had more or less of an effect where there were already more people and/or tillage acres under potato crop.[4] Including the fraction of total baronial or PLU border length shared with other baronies or PLUs with at least one Loan Fund during the famine allows us to control for possible spatial autocorrelation or border effects.

Along these observable dimensions, in Eqs. (5.1) and (5.2), baronies and PLUs with or without a Loan Fund during the famine, and with higher or lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class, are allowed to experience systematically different relative changes after 1845, with the identification assumption that districts with or without a Loan Fund, or with higher or lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class before the famine, but in the same region and with the same levels of blight infection, would otherwise have followed similar trajectories in population change and adjustment in land use if not for differential access to Loan Fund credit and different initial levels of wealth and poverty.

[3] Though the main sample of blight severity includes 255 observations at the baronial level, and the secondary sample includes 105 observations at the PLU level, the number of observations for all baronial and PLU regressions are fewer than 255 and 105, respectively. This owes to the fact that baronies or PLUs missing pre-famine observations of included outcome or control variables are automatically excluded.

[4] Data limitations do not permit us to include pre-famine observations of farm size and livestock holdings.

The coefficients φ_{2mt} and φ_{3mt} in Eq. (5.1) and φ_{2mt} in Eq. (5.2) report whether baronies and PLUs suffering from medium-, high-, or medium-high-blight infection, respectively, in 1845 and 1846 changed differently than baronies and PLUs with low- or low-medium-blight infection where there was higher literacy, potato dependency, population density, valuation, and share of housing rated fourth class before the famine, compared to differences in changes between medium-, high-, or medium-high-infection and low- or low-medium-infection baronies or PLUs where there was lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class. In this way, the coefficients φ_{2mt} and φ_{3mt} in Eq. (5.1) and φ_{2mt} in Eq. (5.2) compare average changes in worse infected baronies or PLUs with higher literacy, potato dependency, population density, valuation, and share of housing rated fourth class relative to less infected baronies or PLUs with higher literacy, potato dependency, population density, valuation, and share of housing rated fourth class, versus average changes in worse infected baronies or PLUs with lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class relative to less infected baronies or PLUs with lower literacy, potato dependency, population density, valuation, and share of housing rated fourth class.

As in Chap. 3, because it is a strong identifying assumption that the establishment of a Loan Fund was uncorrelated with other, unobservable, non-fixed baronial characteristics that might have been correlated with differential responses to blight, as in Chap. 3, I estimate Eqs. (5.1) and (5.2) by two-stage least squares regression, using the presence of an Association of Irish Musical Societies (AIMS) musical society in a given barony or PLU to instrument for the presence of a Loan Fund during the famine. Because Eqs. (5.1) and (5.2) include numerous interactions with Loan Fund presence as explanatory variables, instruments are AIMS musical society presence (M_b), as well as interactions of AIMS musical society presence with blight ($M_b \times B_b^{med}$ and $M_b \times B_b^{high}$), and lags of pre-famine outcomes ($M_b \times y_{bt-n}$). The first stage therefore consists of separately regressing each endogenous regressor ($L_b, L_b \times B_b^{med}, L_b \times B_b^{high}, L_b \times y_{bt-n}$, and $BORD_b$) on all instruments ($M_b, M_b \times B_b^{med}, M_b \times B_b^{high}, M_b \times y_{bt-n}$, and $BORD_M_b$) and all exogenous regressors to generate fitted values.

Several additional estimation details are worth noting. First, regressions for livestock outcomes are subdivided by farm size to allow for average effects to differ for different types of farms.[5] Second, the outcome years analyzed are selected so as to, where possible, estimate average effects 1, 5, 10, 20, and 40 years after the end of the famine in 1851. Where it is possible to analyze outcomes between 1845 and 1851—in other words, during the famine years—I do so. Third, standard errors are clustered at the baronial level (PLU-level for estimations of Eq. 5.2) to adjust for heteroskedasticity and within-barony or within-PLU correlation over time.

5.2 Results

5.2.1 Literacy

Results presented in Tables 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6 reveal that higher adult literacy rates were associated with lower cumulative population declines in the presence of more severe blight infection, though higher adult literacy rates do not appear to have been associated with the mechanisms of adjustment to blight identified in Chaps. 2 and 3, namely, earlier and more substantial crop substitutions, transition to pasture, and the short-run accumulation of buffer livestock assets.

Table 5.1 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in baronial population in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients in Panels A and B, column 1 of Table 5.1, show that the population decline between 1841 and 1851, relative to low-blight baronies, was smaller by 108.056 and 125.768 persons in high- and medium-blight baronies with adult literacy higher by 1 percentage point, versus high- and medium-blight baronies with a 1-percentage point lower literacy rate. Estimated coefficients reported in Panels A and B, column 5, further indicate persistence

[5] Available data do not allow us to distinguish average changes in population and crop acreage by farm size.

Table 5.1 Estimated changes in population by blight severity interacted with pre-famine characteristics

	1851	1861	1871	1881	1891
	(1)	(2)	(3)	(4)	(5)
A. High vs. low					
Literacy	10,805.581*	14,540.542**	29,234.189***	19,827.028**	14,540.542**
	(6139.99)	(7178.49)	(7648.55)	(7815.43)	(7178.49)
Population	–35,417.496	–23,516.466	–39,559.241	–6480.623	–23,516.466
density	(23,346.71)	(33,239.81)	(37,934.01)	(40,980.48)	(33,239.81)
Potato	219,865.647	175,300.245	302,738.62	21,808.127	175,300.245
dependence	(149,506.66)	(215,974.86)	(241,340.83)	(258,240.67)	(215,974.86)
Valuation	–23,854.556	–16,040.122	–31,201.356	2761.064	–16,040.122
	(21,563.21)	(31,267.49)	(34,901.37)	(37,342.77)	(31,267.49)
Fourth class	59,141.832	50,709.195	101,126.010	– 6632.667	50,709.195
	(62,111.32)	(90,695.06)	(100,631.12)	(107,415.60)	(90,695.06)
B. Medium vs. low					
Literacy	12,576.816	17,182.158*	32,892.091***	25,331.204**	17,182.158*
	(7657.74)	(9118.30)	(9789.10)	(10,217.14)	(9118.30)
Population	–38,584.724	–26,177.598	–41,949.388	–7879.337	– 26,177.598
density	(23,367.65)	(32,937.46)	(37,260.47)	(40,217.23)	(32,937.46)
Potato	212,039.805	154,523.708	276,981.625	–5608.298	154,523.708
dependence	(150,497.27)	(215,721.08)	(240,717.54)	(257,225.20)	(215,721.08)
Valuation	–23,503.777	–16,257.791	–30,765.528	3805.552	–16,257.791
	(21,590.26)	(31,388.36)	(35,010.57)	(37,380.18)	(31,388.36)

(*continued*)

Table 5.1 (continued)

	1851	1861	1871	1881	1891
	(1)	(2)	(3)	(4)	(5)
Fourth class	61,037.167	50,485.976	100,248.070	−6289.163	50,485.976
	(61,714.72)	(89,893.36)	(99,774.33)	(106,418.89)	(89,893.36)
N	184	184	183	183	184
R^2	0.678	0.701	0.724	0.740	0.701

Notes: Each column reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) in the text) for changes in population in the indicated year by blight severity interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. All regressions also include Loan Fund presence during the famine, instrumented by AIMS musical society presence, and the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Loan Fund presence is also fully interacted with available pre-famine lags of the indicated outcome variable. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 5.2 Estimated changes in crop acreage by blight severity interacted with pre-famine characteristics

	1846	1847	1848	1849	1852	1856	1861	1871	1891
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. High vs. low									
Literacy	0.333*				0.503	0.407	0.504	0.247*	
	(0.18)				(0.46)	(0.45)	(0.45)	(0.15)	
Population	–0.158**				–0.528**	–0.107	–0.036	–0.162	
density	(0.08)				(0.25)	(0.29)	(0.25)	(0.12)	
Potato	1.366***				0.824	–3.828***	–3.005***	–1.883***	
dependence	(0.26)				(1.06)	(1.35)	(1.11)	(0.65)	
Valuation	–0.173***				–0.136	0.479***	0.376***	0.256***	
	(0.02)				(0.10)	(0.13)	(0.10)	(0.04)	
Fourth class	0.680***				0.692	–1.143*	–0.760	–0.699***	
	(0.19)				(0.57)	(0.61)	(0.56)	(0.20)	
B. Medium vs. low									
Literacy	0.333***				0.220	0.109	0.214	0.201	
	(0.10)				(0.28)	(0.28)	(0.27)	(0.23)	
Population	–0.142*				–0.194	0.299	0.340	0.221	
density	(0.08)				(0.27)	(0.31)	(0.28)	(0.17)	

(*continued*)

Table 5.2 (continued)

	1846	1847	1848	1849	1852	1856	1861	1871	1891
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Potato dependence	1.675***				1.454	−3.377**	−2.451**	−1.542**	
	(0.35)				(1.22)	(1.44)	(1.22)	(0.67)	
Valuation	−0.174***				−0.138	0.467***	0.365***	0.247***	
	(0.02)				(0.10)	(0.13)	(0.10)	(0.04)	
Fourth class	0.631***				0.435	−1.363***	−0.984**	−0.685***	
	(0.11)				(0.38)	(0.46)	(0.38)	(0.19)	
C. High-medium vs. low-medium									
Population density	0.014	−0.007	0.007	0.005	0.018	−0.009	0.012	−0.003	−0.011
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Potato dependence	0.052	0.008	−0.143***	−0.011	−0.058**	−0.177***	−0.168***	−0.142***	−0.143***
	(0.04)	(0.05)	(0.05)	(0.02)	(0.03)	(0.05)	(0.04)	(0.05)	(0.05)
Valuation	−0.004	0.006	0.007	−0.002	−0.001	0.003	0.002	0.008	0.017
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	202 (A, B) / 95 (C)	95	95	95	202 (A, B) / 95 (C)	202 (A, B) / 95 (C)	202 (A, B) / 95 (C)	202 (A, B) / 95 (C)	95
R^2	0.428 (A, B) / 0.715 (C)	0.983	0.985	0.994	0.589 (A, B) / 0.972 (C)	0.614 (A, B) / 0.937 (C)	0.606 (A, B) / 0.951 (C)	0.6717 (A, B) / 0.950 (C)	0.962

Notes: Each column reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) and φ_{2mt}'s from Eq. (5.2) in the text) for changes in crop acreage in the indicated year by blight severity interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class (Eq. 5.1) and pre-famine potato crop share of total tillage acreage, population density, and valuation (Eq. 5.2). All regressions also include Loan Fund presence during the famine, instrumented by AIMS musical society presence, and the fraction of total baronial (Eq. 5.1) or PLU (Eq. 5.2) border length shared with other baronies or PLUs with at least one Loan Fund during the famine, and PLU and county (Eq. 5.1) or county (Eq. 5.2). Loan Fund presence is also fully interacted with available pre-famine lags of the indicated outcome variable. Robust standard errors are reported in parentheses and clustered at the baronial or PLU level. ***p< 0.01, **p < 0.05, *p < 0.10

in the smaller relative population decline in more literate baronies. By 1891, the cumulative population decline, relative to low-blight baronies, was still smaller by 145.405 and 171.822 persons in high- and medium-blight baronies with adult literacy higher by 1 percentage point, versus high- and medium-blight baronies with a 1-percentage point lower literacy rate.

Higher literacy, however, does not appear to have been associated with larger or more rapid relative crop portfolio diversification. Table 5.2 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) and φ_{2mt}'s from Eq. (5.2)) for changes in the fraction of total acreage under tillage crop allocated to potato cultivation in the indicated year by high (Panel A), medium (Panel B), and medium-high (Panel C) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class (Panels A and B) or potato crop share of total tillage acreage, population density, and valuation (Panel C). Estimated coefficients reported in Panels A and B, column 1 of Table 5.2, show that after the first year of blight, high- and medium-blight baronies with adult literacy higher by 1 percentage point relatively increased the fraction of tillage acreage allocated to the potato crop by 0.003 percentage points more than high- and medium-blight baronies with a 1-percentage point lower literacy rate. Estimated coefficients reported in columns 5 through 8, however, indicate that by the end of the famine and through 1871, worse affected baronies with higher rates of adult literacy did not experience systematically different relative changes in crop acreage allocation than worse affected baronies with lower literacy rates.

Table 5.3 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of buffer livestock holdings by farms under 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.3 indicate that higher literacy had ambiguous effects on relative changes in buffer livestock (poultry and swine) holdings by farms under 15 acres in worse affected baronies. By 1849, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high-blight baronies with adult literacy

Table 5.3 Estimated changes in buffer livestock assets by blight severity interacted with pre-famine characteristics (farms <15 acres)

	1848	1849	1850	1852	1856	1861	1871
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. High vs. low							
Literacy	−475.975	1717.828**	1106.603	−200.011	3348.457***	1691.612	4629.193**
	(696.59)	(869.41)	(675.59)	(828.99)	(920.98)	(1054.01)	(1860.77)
Population	−747.467	2052.894**	228.778	3674.712***	2240.476***	1510.575	6838.188***
density	(1408.92)	(804.10)	(1049.64)	(1273.63)	(852.52)	(1256.60)	(2040.88)
Potato	19,760.501***	404.133	24,026.917***	−3963.436	−7440.157**	5853.160	−33,766.730***
dependence	(7534.69)	(967.92)	(4328.76)	(5635.44)	(3234.06)	(5333.16)	(8075.07)
Valuation	−3299.832***	−865.039***	−3122.845***	45.496	1653.044***	−311.907	5369.038***
	(811.43)	(251.48)	(471.34)	(589.83)	(269.04)	(552.82)	(818.55)
Fourth class	10,136.845***	7217.317***	12,550.809***	4190.430**	1966.061	6551.691***	−3402.388
	(2548.53)	(1121.70)	(1535.66)	(2018.69)	(1356.98)	(2060.20)	(3217.66)
B. Medium vs. low							
Literacy	−588.401	732.548	−80.407	−260.992	3437.825***	857.442	2529.55
	(742.28)	(1031.17)	(1063.75)	(1167.96)	(1116.13)	(1608.61)	(2637.22)
Population	−948.786	972.377	−1164.517	2215.504**	1120.103	115.915	4701.707***
density	(1395.43)	(655.52)	(858.70)	(1105.73)	(709.30)	(1094.06)	(1710.67)
Potato	19,529.185**	−1313.710	21,011.838***	−6786.310	−9510.641***	2932.650	−38,317.747***
dependence	(7552.39)	(1054.61)	(4456.60)	(5743.22)	(3167.48)	(5648.29)	(8494.80)

Valuation	−3526.850***	−1291.012***	−3471.990***	−307.560	1211.140***	−763.515	4526.924***
	(810.71)	(162.97)	(441.24)	(571.02)	(231.89)	(537.16)	(764.76)
Fourth class	10,280.753***	7021.100***	12,061.343***	4388.822**	2373.510**	7566.900***	−3062.545
	(2549.78)	(1104.78)	(1578.32)	(1959.18)	(1151.26)	(2060.37)	(3120.15)
N	202	202	202	200	202	202	201
R^2	0.246	0.222	0.201	0.148	0.142	0.194	0.177

Notes: Each column reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) in the text) for changes in the value of buffer livestock holdings by farms under 15 acres in the indicated year by blight severity interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. All regressions also include Loan Fund presence during the famine, instrumented by AIMS musical society presence, and the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Loan Fund presence is also fully interacted with available pre-famine lags of the indicated outcome variable. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 5.4 Estimated changes in grazing livestock assets by blight severity interacted with pre-famine characteristics (farms <15 acres)

	1848	1849	1850	1852	1856	1861	1871
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. High vs. low							
Literacy	−20,914.576***	−15,466.956***	−28,704.305***	−38,598.947***	−22,268.559***	−23,857.640***	−21,447.271**
	(4258.79)	(4679.45)	(6689.05)	(5193.59)	(6370.84)	(6383.96)	(8334.68)
Population	36,049.199***	1201.860	1566.881	−5303.403	−345.949	4810.001	9611.786
density	(6548.04)	(3235.57)	(9252.40)	(5416.22)	(5364.98)	(6298.66)	(7212.24)
Potato	−229,067.463***	1139.968	18,465.135	19,905.428	9639.872	5371.997	27,280.866
dependence	(34,170.15)	(5879.92)	(48,107.28)	(26,819.42)	(24,906.74)	(30,268.76)	(31,478.12)
Valuation	23,524.617***	−1342.046	−5741.657	−3145.915	−1247.028	−3159.108	1495.207
	(3688.70)	(1491.63)	(5309.03)	(2674.61)	(2340.49)	(3456.50)	(3400.18)
Fourth class	−79,667.907***	−4080.563	−5210.975	−10,649.779	156.112	−2195.745	−8089.432
	(12,071.31)	(5587.84)	(16,694.57)	(9225.64)	(9393.82)	(10,673.21)	(11,723.98)
B. Medium vs. low							
Literacy	−22,439.674***	−18,801.031***	−33,279.204***	−46,701.806***	−28,730.442***	−39,315.883***	−43,812.282***
	(5714.31)	(6730.24)	(8015.91)	(7738.02)	(8245.94)	(8641.87)	(15,306.32)
Population	31,307.358***	−3944.742	−7159.783	−14,135.848**	−5130.915	114.708	3209.773
density	(6863.07)	(4306.22)	(10,044.33)	(6753.18)	(5938.35)	(7284.54)	(8781.74)

Potato dependence	−206,755.803*** (35,316.39)	19,011.210* (11,383.82)	36,207.148 (49,467.78)	29,632.540 (27,498.18)	14,259.100 (24,034.76)	2006.302 (31,607.90)	51,253.496 (39,267.10)
Valuation	23,729.376*** (3666.73)	−1927.157* (1080.38)	−6065.700 (5117.59)	−3949.333 (2437.46)	−1778.560 (1558.66)	−2410.820 (2860.31)	1396.933 (2612.74)
Fourth class	−92,899.623*** (12,644.94)	−16,684.238** (7608.75)	−16,957.675 (17,250.32	−25,735.023** (9990.15)	−15,345.625** (7474.66)	−14,480.469 (10,369.43	−15,281.229 (11,477.55
N	202	202	202	200	202	202	201
R^2	0.256	0.176	0.124	0.117	0.099	0.108	0.183

Notes: Each column reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) in the text) for changes in the value of grazing livestock holdings by farms under 15 acres in the indicated year by blight severity interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. All regressions also include Loan Fund presence during the famine, instrumented by AIMS musical society presence, and the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Loan Fund presence is also fully interacted with available pre-famine lags of the indicated outcome variable. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 5.5 Estimated changes in buffer livestock assets by blight severity interacted with pre-famine characteristics (farms >15 acres)

	1848	1849	1850	1852	1856	1861	1871
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. High vs. low							
Literacy	1602.774**	18,906.588***	4620.361**	4450.256***	8884.995***	14,377.830***	22,573.397***
	(645.69)	(910.72)	(1878.48)	(1482.19)	(1963.92)	(3792.34)	(7961.00)
Population	−10,864.952***	−2186.123***	−14,263.569***	−5612.141***	−2219.500	−10,534.968	791.319
density	(544.60)	(644.99)	(3373.92)	(2117.44)	(3278.34)	(7634.22)	(16,372.51)
Potato	103,305.736***	118.431	166,432.422***	60,521.714***	24,128.762	115,570.767***	36,324.014
dependence	(2040.41)	(1426.72)	(18,036.57)	(10,985.15)	(17,489.12)	(41,205.51)	(88,533.82)
Valuation	−14,423.840***	−6422.402***	−24,002.206***	−9876.214***	−3051.135	−15,197.209***	−6436.725
	(205.22)	(296.07)	(1943.25)	(1181.94)	(1880.89)	(4440.72)	(9542.65)
Fourth class	46,910.035***	43,794.601***	76,198.518***	33,449.930***	15,838.466***	50,904.924***	32,185.957
	(813.53)	(1136.20)	(6116.29)	(3849.63)	(6014.73)	(13,959.00)	(29,924.10)
B. Medium vs. low							
Literacy	1771.854*	19,060.768***	6115.391***	5566.923***	10,343.253***	17,024.899***	27,355.165***
	(965.54)	(1313.17)	(2223.89)	(1966.05)	(2250.20)	(4098.58)	(8208.74)
Population	−10,469.295***	−1988.963**	−14,541.643***	−5969.655***	−1780.395	−12,598.919	−1911.423
density	(664.14)	(845.92)	(3446.22)	(2262.87)	(3371.07)	(7727.20)	(16,509.21)
Potato	102,308.399***	1006.728	170,634.791***	65,015.901***	26,016.595	128,752.342***	57,877.488
dependence	(2597.18)	(1894.34)	(18,141.58)	(11,312.09)	(17,640.49)	(41,521.70)	(88,951.58)

Valuation	−14,572.962***	−6670.736***	−24,325.210***	−10,151.673***	−3302.207*	−14,993.932***	−6509.228
	(183.47)	(211.50)	(1927.91)	(1168.58)	(1872.52)	(4439.85)	(9543.92)
Fourth class	47,134.335***	44,373.197***	77,290.985***	34,884.670***	17,583.251***	53,835.471***	35,790.526
	(1084.45)	(1345.25)	(6207.93)	(3998.15)	(6053.41)	(14,035.86)	(30,066.18)
N	202	202	202	200	202	202	201
R^2	0.330	0.428	0.370	0.369	0.351	0.409	0.359

Notes: Each column reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) in the text) for changes in the value of buffer livestock holdings by farms over 15 acres in the indicated year by blight severity interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. All regressions also include Loan Fund presence during the famine, instrumented by AIMS musical society presence, and the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Loan Fund presence is also fully interacted with available pre-famine lags of the indicated outcome variable. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 5.6 Estimated changes in grazing livestock assets by blight severity interacted with pre-famine characteristics (farms >15 acres)

	1848	1849	1850	1852	1856	1861	1871
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. High vs. low							
Literacy	−65,032.592**	−33,283.611	−70,072.209***	−63,620.063***	−57,356.121	−77,147.331**	18,324.181
	(25,594.48)	(21,118.57)	(13,263.67)	(19,666.98)	(38,089.30)	(32,901.50)	(43,289.93)
Population	149,248.739***	45,739.277***	86,820.214***	199,602.248***	206,144.788***	152,672.899***	228,868.193***
density	(52,774.73)	(15,275.40)	(10,266.35)	(20,949.67)	(63,133.82)	(54,490.73)	(73,391.56)
Potato	−90,7602.963***	−31,133.982*	−733,485.395***	−1,671,422.694***	−1,452,361.312***	−940,161.232***	−1,699,433.178***
dependence	(285,807.82)	(15,909.45)	(43,165.32)	(106,144.10)	(338,391.89)	(291,329.72)	(394,033.94)
Valuation	98,512.073***	11,595.631***	88,979.060***	211,341.212***	173,678.230***	101,571.776***	204,682.568***
	(30,832.58)	(4254.28)	(4536.08)	(11,491.51)	(36,503.73)	(31,413.34)	(42,553.35)
Fourth class	−302,809.529***	−663.38	−204,174.551***	−594,162.771***	−497,311.400***	−295,887.643***	−526,001.641***
	(96,552.29)	(25,671.12)	(17,603.66)	(38,677.41)	(116,099.57)	(100,081.93)	(134,877.38)
B. Medium vs. low							
Literacy	−70,220.799***	−24,832.809	−50,630.645***	−41,722.078*	−24,090.759	−55,298.238	45,982.024
	(26,738.42)	(24,383.88)	(17,633.63)	(23,882.26)	(39,519.95)	(36,725.46)	(46,343.95)
Population	154,763.046***	57,122.548***	93,881.382***	204,126.719***	198,818.980***	143,057.640**	225,628.275***
density	(52,980.21)	(16,547.70)	(11,828.10)	(22,327.65)	(64,082.95)	(55,611.22)	(75,200.91)
Potato	−888,746.027***	−34,890.911	−710,078.335***	−1,651,275.830***	−1,405,789.274***	−912,752.893***	−1,649,978.637***
dependence	(286,478.91)	(25,979.89)	(50,590.91)	(115,195.41)	(341,986.76)	(296,168.13)	(399,190.34)

Valuation	98,141.570***	8360.709**	83,251.967***	207,038.481***	167,223.448***	98,876.896***	200,895.655***
	(30,802.43)	(4117.64)	(4221.91)	(11,224.49)	(36,262.45)	(31,293.88)	(42,398.01)
Fourth class	–308,948.258***	–4865.753	–212,025.147***	–583,142.033***	–461,872.574***	–268,049.099***	–487,474.093***
	(96,710.21)	(27,051.16)	(19,767.89)	(40,844.28)	(116,787.05)	(101,168.91)	(136,440.38)
N	202	202	202	200	202	202	201
R^2	0.153	0.189	0.317	0.423	0.439	0.428	0.435

Notes: Each column reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) in the text) for changes in the value of grazing livestock holdings by farms over 15 acres in the indicated year by blight severity interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. All regressions also include Loan Fund presence during the famine, instrumented by AIMS musical society presence, and the fraction of total baronial border length shared with other baronies with at least one Loan Fund during the famine, and PLU and county. Loan Fund presence is also fully interacted with available pre-famine lags of the indicated outcome variable. Robust standard errors are reported in parentheses and clustered at the baronial level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

rates higher by 1 percentage point had increased the value of buffer livestock holdings by £17.178 more than farms under 15 acres in high-blight baronies with a 1-percentage point lower literacy rate, though no similar estimated relative effect is observed among medium-blight baronies. After dissipating through 1852, by 1856, the estimated effects of a 1-percentage point higher literacy rate on relative accumulations of buffer livestock by farms under 15 acres in high- and medium-blight baronies were £33.48 and £34.38, respectively. In other words, by 1856, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with adult literacy rates higher by 1 percentage point had increased the value of buffer livestock holdings by £33.48 and £34.38 more, respectively, than farms under 15 acres in high-blight baronies with a 1-percentage point lower literacy rate. Estimated coefficients reported in Panels A and B, column 7 of Table 5.3 show these effects of blight persisting through 1871.

Estimated coefficients reported in Table 5.4, meanwhile, indicate a large and significant association between higher literacy and relative reductions in the value of grazing livestock (cattle, sheep, and goats) holdings by farms under 15 acres in worse affected baronies. Table 5.4 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of grazing livestock holdings by farms under 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Already by 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with adult literacy rates higher by 1 percentage point had reduced the value of grazing livestock holdings by £209.16 and £224.40 more, respectively, than farms under 15 acres in high-blight baronies with a 1-percentage point lower literacy rate. This large and statistically significant estimated effect of higher literacy on relative changes in holdings of grazing livestock assets in worse affected baronies furthermore appears to have persisted through the medium and long runs. By 1871, the relative reduction in grazing livestock holdings by farms under 15 acres in high- and medium-blight baronies with a 1-percentage point higher adult literacy rate was still greater by £214.47 and £438.12, respectively, than by farms under 15

acres in high- and medium-blight baronies with a 1-percentage point lower adult literacy rate.

Table 5.5 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of buffer livestock holdings by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.5 indicate that higher literacy had significant positive effects on relative accumulations of buffer livestock (poultry and swine) holdings by farms over 15 acres in worse affected baronies in the short, medium, and long runs. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with adult literacy rates higher by 1 percentage point had increased the value of buffer livestock holdings by £16.03 and £17.72 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower literacy rate. Estimated coefficients reported in columns 2 through 7 of Table 5.5 furthermore show the estimated relative accumulation of buffer livestock holdings by farms over 15 acres in worse affected baronies with higher pre-famine adult literacy rates persisting and even growing through the very long run. By 1871, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with adult literacy rates higher by 1 percentage point had increased the value of buffer livestock holdings by £225.73 and £273.55 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower literacy rate.

Estimated coefficients reported in Table 5.6, meanwhile, indicate a large and significant association between higher literacy and relative reductions in the value of grazing livestock (cattle, sheep, and goats) holdings by farms over 15 acres in worse affected baronies. Table 5.6 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of grazing livestock holdings by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Already by 1848, relative to farms over 15 acres in low-blight baronies, farms over

15 acres in high- and medium-blight baronies with adult literacy rates higher by 1 percentage point had reduced the value of grazing livestock holdings by £650.33 and £702.21 more, respectively, than farms over 15 acres in high-blight baronies with a 1-percentage point lower literacy rate. This large and statistically significant estimated effect of higher literacy on changes in holdings of grazing livestock assets in worse affected baronies furthermore appears to have persisted through the medium-to-long run. By 1861, the relative reduction in grazing livestock holdings by farms over 15 acres in high-blight baronies with a 1-percentage point higher adult literacy rate was still greater by £771.47 than by farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower adult literacy rate.

5.2.2 Population Density

Results presented in Tables 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6 reveal that higher pre-famine population density was not associated with systematically different population declines in the presence of more severe blight infection. Nor does higher population density appear to have been associated with differential changes in crop acreage allocation or allocations of grazing livestock where blight infection was more severe. Higher pre-famine population density does, however, seem to have been associated with differential relative accumulations of buffer livestock assets in worse affected baronies.

Table 5.3 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for baronial-level changes in the total value of buffer livestock (poultry and swine) assets held by farms under 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. The estimated coefficient in Panel A, column 2 of Table 5.2, shows that the accumulation of buffer livestock between 1847 and 1849, relative to low-blight baronies, was £2052.89 greater in high-blight baronies with a 1-person-per-acre denser pre-famine population, versus high- and medium-blight baronies with a 1-person-per-acre less dense pre-famine population. By the end of

the famine, in 1852 (Panels A and B, column 4), farms under 15 acres in high- and medium-blight baronies with pre-famine population denser by 1 person per acre had relatively increased buffer livestock holdings by £3674.71 and £2215.50 more, respectively, than high- and medium-blight baronies with pre-famine population less dense by 1 person per acre. Estimated coefficients reported in Panels A and B, column 7, further indicate persistence in the larger relative accumulation of buffer livestock assets in more demographically dense baronies. By 1871, the cumulative increase in buffer livestock holdings by farms under 15 acres in high- and medium-blight baronies, relative to farms under 15 acres in low-blight baronies, was still greater by £6838.19 and £4701.71 where pre-famine population density was greater by 1 person per acre.

In contrast, farms under 15 acres in high- and medium-blight baronies with higher pre-famine population density do not appear to have experienced systematically different relative changes in grazing livestock (cattle, sheep, and goats) holdings beyond 1848. Table 5.4 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of grazing livestock holdings by farms under 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with pre-famine population denser by 1 person per acre had increased the value of grazing livestock holdings by £36,049.20 and £31,307.36 more, respectively, than farms under 15 acres in high- and medium-blight baronies with a pre-famine population less dense by 1 person per acre. This large and statistically significant estimated effect of higher pre-famine population density on changes in holdings of grazing livestock assets in worse affected baronies appears, however, to have dissipated entirely by 1849. Through 1871, the relative reduction in grazing livestock holdings by farms under 15 acres in high- and medium-blight baronies with a 1-person-per-acre higher pre-famine population was still greater by £21,447.27 and £43,812.28, respectively, than by farms under 15 acres in high- and medium-blight baronies with a 1-person-per-acre less dense pre-famine population.

Table 5.5 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for baronial-level changes in the total value of buffer livestock (poultry and swine) assets held by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients indicate that farms over 15 acres in high- and medium-blight baronies with higher pre-famine population density experienced relative reductions in the value of grazing livestock (cattle, sheep, and goats) holdings in the short-to-medium run. By 1848, the reduction in buffer livestock assets, relative to low-blight baronies, was £10,864.95 and £10,469.30 greater, respectively, among farms over 15 acres in high- and medium-blight baronies with a 1-person-per-acre denser pre-famine population, versus farms over 15 acres in high- and medium-blight baronies with a 1-person-per-acre less dense pre-famine population. By the end of the famine, in 1852 (Panels A and B, column 4), farms over 15 acres in high- and medium-blight baronies with pre-famine population denser by 1 person per acre had relatively decreased buffer livestock holdings by £5612.14 and £5969.66 more, respectively, than farms over 15 acres in high- and medium-blight baronies with pre-famine population less dense by 1 person per acre. Estimated coefficients reported in Panels A and B, columns 5 through 7, however, suggest that beyond the medium run, the greater relative reduction in buffer livestock assets by farms over 15 acres in worse affected baronies with higher pre-famine population density dissipated. By 1871, the relative change in buffer livestock holdings by farms over 15 acres in high- and medium-blight baronies, relative to farms over 15 acres in low-blight baronies, was statistically no different where pre-famine population was more versus less dense.

In contrast, farms over 15 acres in high- and medium-blight baronies with higher pre-famine population density experienced significant relative increases in grazing livestock (cattle, sheep, and goats) holdings in both the short and long runs. Table 5.6 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of grazing livestock holdings by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation,

and share of housing rated fourth class. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with pre-famine population denser by 1 person per acre had increased the value of grazing livestock holdings by £149,248.74 and £154,763.05 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a pre-famine population less dense by 1 person per acre. This large and statistically significant estimated effect of higher pre-famine population density on the relative accumulation of holdings of grazing livestock assets in worse affected baronies appears, moreover, to have persisted through the medium and long runs. By 1871, the relative increase in grazing livestock holdings by farms over 15 acres in high- and medium-blight baronies with a 1-person-per-acre higher pre-famine population was still greater by £228,868.19 and £225,628.28, respectively, than by farms over 15 acres in high- and medium-blight baronies with a 1-person-per-acre less dense pre-famine population.

Estimated coefficients reported in Tables 5.1 and 5.2, meanwhile, suggest that pre-famine population density was not associated with differential changes in population or crop acreage allocation in high- and medium-blight baronies, relative to low-blight baronies. Table 5.1 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in baronial population in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Table 5.2 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) and φ_{2mt}'s from Eq. (5.2)) for changes in the fraction of total acreage under tillage crop allocated to potato cultivation in the indicated year by high (Panel A), medium (Panel B), and medium-high (Panel C) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class (Panels A and B) or potato crop share of total tillage acreage, population density, and valuation (Panel C). Estimated coefficients reported in both tables are generally not statistically significant and vary in sign.

5.2.3 Potato Dependence

Results presented in Tables 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6 reveal that a greater pre-famine reliance on the potato crop, as a percentage of total acreage under tillage, was associated with differential relative changes in the value of buffer and grazing livestock holdings, as well as in crop acreage allocation, in districts worse affected by blight. Greater pre-famine allocation of crop acreage to the potato does not, however, appear to have been associated with systematically different population declines in the presence of more severe blight infection.

Table 5.1 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in baronial population in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients in Panels A and B, column 1 of Table 5.1, show that the population decline between 1841 and 1851, relative to low-blight baronies, was statistically no different in high- and medium-blight baronies with acreage allocation to the potato higher by 1 percentage point, versus high- and medium-blight baronies with a 1-percentage point lower crop acreage allocation to the potato. Estimated coefficients reported in Panels A and B, columns 2 through 5, further indicate no long-run difference in relative population declines in worse infected baronies more dependent on the potato before the famine. By 1891, the cumulative population decline, relative to low-blight baronies, was still statistically no different in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point, versus high- and medium-blight baronies with a 1-percentage point lower potato acreage allocation.

Higher potato dependence, however, does appear to have been associated with differential relative changes in crop portfolios. Table 5.2 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) and φ_{2mt}'s from Eq. (5.2)) for changes in the fraction of total acreage under tillage crop allocated to potato cultivation in the indicated year by high (Panel A), medium (Panel B), and medium-high (Panel C) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population

density, valuation, and share of housing rated fourth class (Panels A and B) or potato crop share of total tillage acreage, population density, and valuation (Panel C). Estimated coefficients reported in Panels A and B, column 1 of Table 5.2, show that after the first year of blight, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively increased the fraction of tillage acreage allocated to the potato crop by 1.366 and 1.675 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation. Estimated coefficients at the PLU level reported in Panel A, column 1, similarly suggest a short-run relative allocation toward the potato in worse affected districts with higher pre-famine potato dependence.

Estimated coefficients reported in Panels A, B, and C, columns 6 through 9 of Table 5.2, however, reveal a longer-run substitution away from the potato crop in worse affected districts with higher pre-famine potato dependence, relative to less infected districts. By 1856, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively reduced the fraction of tillage acreage allocated to the potato crop by 3.828 and 3.377 percentage points more than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation. In the very long run, through 1871, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively reduced the fraction of tillage acreage allocated to the potato crop by 1.833 and 1.542 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation.

Estimated coefficients reported in Table 5.3 indicate that greater pre-famine potato dependence also had significant effects on relative changes in buffer livestock (poultry and swine) holdings by farms under 15 acres in worse affected baronies. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had increased the value of buffer livestock holdings by £197.61 and £195.29 more, respectively, than farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower

pre-famine acreage allocation to the potato. This effect appears to have persisted through the medium run; by 1850, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had increased the value of buffer livestock holdings by £240.27 and £210.12 more, respectively, than farms under 15 acres in high-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato.

Over the long run, however, greater pre-famine reliance on the potato as a percentage of total acreage under tillage was associated with relative reductions in buffer livestock assets held by farms under 15 acres in worse affected baronies. Specifically, estimated coefficients reported in Panels A and B, column 7 of Table 5.3, show that by 1871, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had reduced the value of buffer livestock holdings by £337.67 and £383.18 more, respectively, than farms under 15 acres in high-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato.

Estimated coefficients reported in Table 5.4, meanwhile, indicate a large and significant short-run association between higher pre-famine potato dependence and relative reductions in the value of grazing livestock (cattle, sheep, and goats) holdings by farms under 15 acres in worse affected baronies. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had reduced the value of grazing livestock holdings by £2290.67 and £2067.56 more, respectively, than farms under 15 acres in high-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato. This large and statistically significant estimated effect of higher potato dependency on changes in holdings of grazing livestock assets in worse affected baronies appears, however, to have dissipated entirely through the medium and long runs, with no medium- or long-run difference in relative changes in the value of grazing livestock holdings by farms under 15 acres in high- and medium-blight baronies with higher pre-famine potato dependence versus farms under 15 acres

in high- and medium-blight baronies with lower pre-famine potato dependence.

Table 5.5 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for baronial-level changes in the total value of buffer livestock (poultry and swine) assets held by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.5 indicate that greater pre-famine potato dependence also had significant effects on relative changes in buffer livestock (poultry and swine) holdings by farms over 15 acres in worse affected baronies, in both the short and long runs. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had increased the value of buffer livestock holdings by £1033.06 and £1023.08 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato. This effect appears to have persisted through the long, though not very long, run; by 1861, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had increased the value of buffer livestock holdings by £1155.71 and £1287.52 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato.

Estimated coefficients reported in Table 5.6, meanwhile, indicate a large and significant short-run association between higher pre-famine potato dependence and relative reductions in the value of grazing livestock (cattle, sheep, and goats) holdings by farms over 15 acres in worse affected baronies. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had reduced the value of grazing livestock holdings by £9076.03 and £8887.46 more, respectively, than farms over 15 acres in high-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato. This large and statistically significant estimated effect of

higher potato dependency on changes in holdings of grazing livestock assets in worse affected baronies appears to have persisted through the long run. As late as 1871, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point had reduced the value of buffer livestock holdings by £16,994.33 and £16,499.79 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower pre-famine acreage allocation to the potato.

5.2.4 Valuation

Results presented in Tables 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6 reveal that higher pre-famine baronial and PLU valuations were associated with differential relative changes in the value of buffer and grazing livestock holdings, as well as in crop acreage allocation, in districts worse affected by blight. Greater pre-famine district valuations do not, however, appear to have been associated with systematically different population declines in the presence of more severe blight infection.

Table 5.1 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in baronial population in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients in Panels A and B, column 1 of Table 5.1, show that the population decline between 1841 and 1851, relative to low-blight baronies, was statistically no different in high- and medium-blight baronies with pre-famine valuations higher by 1 %, versus high- and medium-blight baronies with 1 % lower pre-famine valuations. Estimated coefficients reported in Panels A and B, columns 2 through 5, further indicate no long-run difference in relative population declines in worse infected baronies with higher valuations before the famine. By 1891, the cumulative population decline, relative to low-blight baronies, was still statistically no different in high- and medium-blight baronies with pre-famine valuations higher by 1 %,

versus high- and medium-blight baronies with 1 % lower pre-famine valuations.

Higher pre-famine valuations do, however, appear to have been associated with differential relative changes in crop portfolios. Table 5.2 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) and φ_{2mt}'s from Eq. (5.2)) for changes in the fraction of total acreage under tillage crop allocated to potato cultivation in the indicated year by high (Panel A), medium (Panel B), and medium-high (Panel C) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class (Panels A and B) or potato crop share of total tillage acreage, population density, and valuation (Panel C). Estimated coefficients reported in Panels A and B, column 1 of Table 5.2, show that after the first year of blight, high- and medium-blight baronies with 10 % higher pre-famine valuations relatively decreased the fraction of tillage acreage allocated to the potato crop by 1.73 and 1.74 percentage points more than high- and medium-blight baronies with 10 % lower pre-famine valuations. Estimated coefficients at the PLU level reported in Panel A, column 1, however, do not similarly suggest a short-run relative allocation away from the potato in worse affected districts with higher pre-famine valuations.

Estimated coefficients reported in Panels A, B, and C, columns 6 through 9 of Table 5.2, though, reveal a longer-run substitution toward the potato crop in worse affected districts with higher pre-famine valuations, relative to less infected districts. By 1856, high- and medium-blight baronies with 10 % higher pre-famine valuations relatively increased the fraction of tillage acreage allocated to the potato crop by 4.79 and 4.67 percentage points more than high- and medium-blight baronies with 10 % lower pre-famine valuations. In the very long run, through 1871, high- and medium-blight baronies with 10 % higher pre-famine valuations relatively increased the fraction of tillage acreage allocated to the potato crop by 2.56 and 2.47 percentage points more, respectively, than high- and medium-blight baronies with 10 % lower pre-famine valuations.

Estimated coefficients reported in Table 5.3 indicate that higher pre-famine valuations had opposite effects on relative changes in buffer livestock (poultry and swine) holdings by farms under 15 acres in worse affected baronies in the short and medium versus long runs. In the short

run, farms under 15 acres in worse affected baronies with higher pre-famine valuations relatively reduced holdings of buffer livestock assets. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with 10 % higher pre-famine valuations had reduced the value of buffer livestock holdings by £329.98 and £352.69 more, respectively, than farms under 15 acres in high- and medium-blight baronies with 10 % lower pre-famine valuations. Estimated coefficients reported in Panels A and B, columns 2 and 3 of Table 5.3, then show the estimated relative reduction in buffer livestock holdings by farms under 15 acres in worse affected baronies with higher pre-famine valuations persisting through 1850.

Estimated coefficients reported in Panels A and B, columns 5 through 7, however, indicate that over the longer run, farms under 15 acres in worse affected districts with higher pre-famine valuations relatively increased buffer livestock holdings. By 1871, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with 10 % higher pre-famine valuations had increased the value of buffer livestock holdings by £536.90 and £452.69 more, respectively, than farms under 15 acres in high- and medium-blight baronies with 10 % lower pre-famine valuations.

Estimated coefficients reported in Table 5.4, meanwhile, indicate a large and significant association between higher pre-famine valuations and relative increases in the value of grazing livestock (cattle, sheep, and goats) holdings by farms under 15 acres in worse affected baronies in the short, but not medium and long runs. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with 10 % higher pre-famine valuations had increased the value of grazing livestock holdings by £2352.46 and £2372.94 more, respectively, than farms under 15 acres in high- and medium-blight baronies with 10 % lower pre-famine valuations. This large and statistically significant estimated effect of higher valuations on relative changes in holdings of grazing livestock assets in worse affected baronies does not, however, appear to have persisted through the medium and long runs. Estimated coefficients reported in columns 2 through 7 of Table 5.4 reveal that after 1848, the relative reduction in grazing livestock holdings by farms under 15 acres in high- and medium-blight baronies

with higher pre-famine valuations was statistically no different from the relative reduction in grazing livestock holdings by farms under 15 acres in high- and medium-blight baronies with lower pre-famine valuations.

Table 5.5 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for baronial-level changes in the total value of buffer livestock (poultry and swine) assets held by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.5 indicate a large and significant short- and long-run association between higher pre-famine valuations and relative reductions in the value of buffer (poultry and swine) holdings by farms over 15 acres in worse affected baronies. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with 10 % higher pre-famine valuations had reduced the value of buffer livestock holdings by £144.24 and £145.73 more than farms under 15 acres in high- and medium-blight baronies with 10 % lower pre-famine valuations. Estimated coefficients reported in Panels A and B, columns 2 through 6 of Table 5.5, moreover, indicate that this effect persisted through the long, though not very long, run. By 1861, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with 10 % higher pre-famine valuations had still reduced the value of buffer livestock holdings by £151.97 and £149.94 more, respectively, than farms over 15 acres in high- and medium-blight baronies with 10 % lower pre-famine valuations.

Table 5.6 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for baronial-level changes in the total value of grazing livestock (cattle, sheep, and goats) assets held by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.6 indicate a large and significant association between higher pre-famine valuations and relative increases in the value of grazing livestock (cattle, sheep, and goats) holdings by farms over 15 acres in worse affected baronies in both the short and long runs. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres

in high- and medium-blight baronies with 10 % higher pre-famine valuations had increased the value of grazing livestock holdings by £985.12 and £981.42 more, respectively, than farms over 15 acres in high- and medium-blight baronies with 10 % lower pre-famine valuations.

This large and statistically significant estimated effect of higher valuations on relative changes in holdings of grazing livestock assets by farms over 15 acres in worse affected baronies appears, moreover, to have persisted through the medium and long runs. Estimated coefficients reported in column 7 of Table 5.6 reveal that as late as 1871, the relative increase in grazing livestock holdings by farms over 15 acres in high- and medium-blight baronies with 10 % higher pre-famine valuations was still £2046.83 and £2008.96 greater, respectively, than the relative increase in grazing livestock holdings by farms over 15 acres in high- and medium-blight baronies with pre-famine valuations lower by 10 %.

5.2.5 Fourth-Class Housing

Results presented in Tables 5.1, 5.2, 5.3, 5.4, 5.5, and 5.6 reveal that higher pre-famine concentrations of fourth-class housing (the lowest-category censal housing designation, defined as "all mud cabins having only one room") were associated with differential relative changes in the value of buffer and grazing livestock holdings, as well as in crop acreage allocation, in districts worse affected by blight. Greater pre-famine concentrations of fourth-class housing do not, however, appear to have been associated with systematically different population declines in the presence of more severe blight infection.

Table 5.1 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in baronial population in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients in Panels A and B, column 1 of Table 5.1, show that the population decline between 1841 and 1851, relative to low-blight baronies, was statistically no different in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock,

versus high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing. Estimated coefficients reported in Panels A and B, columns 2 through 5, further indicate no long-run difference in relative population declines in worse infected baronies with higher concentrations of fourth-class housing before the famine. By 1891, the cumulative population decline, relative to low-blight baronies, was still statistically no different in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock, versus high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Higher pre-famine concentration of fourth-class housing does, however, appear to have been associated with differential relative changes in crop portfolios. Table 5.2 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1) and φ_{2mt}'s from Eq. (5.2)) for changes in the fraction of total acreage under tillage crop allocated to potato cultivation in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class (Panels A and B) or potato crop share of total tillage acreage, population density, and valuation (Panel C). Estimated coefficients reported in Panels A and B, column 1 of Table 5.2, show that after the first year of blight, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively increased the fraction of tillage acreage allocated to the potato crop by 0.680 and 0.631 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Estimated coefficients reported in Panels A and B, columns 6 through 8 of Table 5.2, though, reveal a longer-run substitution away from the potato crop in worse affected districts with higher pre-famine concentrations of fourth-class housing, relative to less infected districts. By 1856, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively reduced the fraction of tillage acreage allocated to the potato crop by 1.143 and 1.363 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower fourth-class

share of total housing. In the very long run, through 1871, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively decreased the fraction of tillage acreage allocated to the potato crop by 0.699 and 0.685 percentage points more than high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Table 5.3 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of buffer livestock holdings by farms under 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.3 indicate that farms under 15 acres in worse affected baronies with higher pre-famine concentrations of fourth-class housing relatively increased stocks of buffer livestock in the short, medium, and long runs, though not over the very long run. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had increased the value of buffer livestock holdings by £101.37 and £102.81 more, respectively, than farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Estimated coefficients reported in Panels A and B, columns 2 through 6, further show this relative accumulation of buffer livestock assets in worse infected baronies with higher concentrations of fourth-class housing persisting through the medium and long runs. By the end of the famine, in 1852, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had increased the value of buffer livestock holdings by £41.90 and £43.89 more, respectively, than farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing. As late as 1861, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had still increased the value

of buffer livestock holdings by £65.52 and £75.67 more, respectively, than farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Over the very long run, however, the estimated effect of higher pre-famine concentrations of fourth-class housing on relative accumulations of buffer livestock among farms under 15 acres in worse affected baronies appears to have dissipated. By 1871, the accumulation of buffer livestock assets, relative to low-blight baronies, was statistically no different among farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock, versus among farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Table 5.4 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of grazing livestock (cattle, sheep, and goats) holdings by farms under 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.4 indicate a large and significant association between a higher pre-famine concentration of fourth-class housing and relative decreases in the value of grazing livestock holdings by farms under 15 acres in worse affected baronies in the short and medium, but not long runs. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had decreased the value of grazing livestock holdings by £796.68 and £929.00 more, respectively, than farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

This large and statistically significant estimated effect of higher pre-famine concentration of fourth-class housing on relative changes in holdings of grazing livestock assets, at least among farms under 15 acres in medium-blight baronies, appears to have persisted through the medium run. The estimated coefficient reported in Panel B, column 5 of Table 5.4, reveals that in 1856, the relative reduction in grazing livestock hold-

ings by farms under 15 acres in medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock was still £153.46 greater than by farms under 15 acres in medium-blight baronies with a 1-percentage point lower fourth-class share of total housing. Estimated coefficients reported in columns 6 and 7 of Table 5.4, however, indicate that beyond 1856, the accumulation of grazing livestock assets, relative to low-blight baronies, was statistically no different among farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock, versus among farms under 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Table 5.5 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of buffer livestock holdings by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.5 indicate that farms over 15 acres in worse affected baronies with higher pre-famine concentrations of fourth-class housing relatively increased stocks of buffer livestock in the short, medium, and long runs. By 1848, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had increased the value of buffer livestock holdings by £469.10 and £ 471.34 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Estimated coefficients reported in Panels A and B, columns 2 through 6, further show this relative increase in buffer livestock assets by farms over 15 acres in worse infected baronies with higher concentrations of fourth-class housing persisting through the medium and long, though not very long, runs. By the end of the famine, in 1852, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had increased the value of buffer livestock holdings by £334.50 and £ 348.85 more,

respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing. As late as 1861, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had still increased the value of buffer livestock holdings by £509.05 and £538.36 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Table 5.6 reports estimated coefficients (φ_{2mt}'s and φ_{3mt}'s from Eq. (5.1)) for changes in the value of grazing livestock (cattle, sheep, and goats) holdings by farms over 15 acres in the indicated year by high (Panel A) and medium (Panel B) blight interacted with pre-famine literacy, potato crop share of total tillage acreage, population density, valuation, and share of housing rated fourth class. Estimated coefficients reported in Table 5.6 indicate a large and significant association between a higher pre-famine concentration of fourth-class housing and relative decreases in the value of grazing livestock holdings by farms over 15 acres in worse affected baronies in the short and long runs. By 1848, relative to farms under 15 acres in low-blight baronies, farms under 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had decreased the value of grazing livestock holdings by £3028.10 and £3089.48 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

This large and statistically significant estimated effect of higher pre-famine concentration of fourth-class housing on relative changes in holdings of grazing livestock assets appears to have persisted through the very long run. By 1871, relative to farms over 15 acres in low-blight baronies, farms over 15 acres in high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock had reduced the value of buffer livestock holdings by £5941.63 and £5831.42 more, respectively, than farms over 15 acres in high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

5.3 Conclusion

As noted in the introduction, the foregoing analysis presents a picture that is generally inconsistent with a predominantly Malthusian account of the Irish Famine. Controlling for the severity of blight infection, access to microfinance credit, regional-time fixed effects, and spatial fixed effects, while it is the case that higher adult literacy was associated with smaller relative population declines in worse affected districts, other traditional "Malthusian" variables do not appear to have been associated with differential demographic changes in districts suffering from more severe blight infection, relative to less severely affected districts. Specifically, the cumulative population decline, relative to low-blight baronies, was still statistically no different in high- and medium-blight baronies with higher pre-famine population density, potato dependence, baronial or Poor Law Union valuations, and fourth-class housing stock versus high- and medium-blight baronies with lower pre-famine population density, potato dependence, baronial or Poor Law Union valuations, and fourth-class housing stock.

Results do, however, suggest that variation in pre-famine Malthusian pressures was associated with differential relative adjustments in land use and livestock acquisition and disposal, particularly over the medium to long runs. While greater pre-famine reliance on the potato crop and higher concentrations of fourth-class housing were associated, in the short run, with greater acreage allocation toward the potato in worse affected districts, over the medium and long runs, worse affected districts with higher pre-famine potato dependence and fourth-class housing substituted crop acreage away from potato cultivation. Meanwhile, parallel to adjustments in crop acreage allocation, greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were also associated with differential changes in livestock assets among farms under 15 acres in worse affected districts. In the short through medium runs, farms under 15 acres in worse affected districts with higher pre-famine potato dependence and fourth-class housing stock, relative to equivalently sized farms in low-blight districts, increased stocks of buffer livestock holdings of chickens and pigs, compared to farms under 15 acres

in worse affected districts with lower potato dependence and fourth-class housing stock. These relative accumulations, however, dissipated over the very long run.

Greater pre-famine potato dependence and fourth-class housing stock were, moreover, associated with greater short-run liquidations of grazing livestock assets by farms under 15 acres in worse affected districts. Higher pre-famine population density and valuations, meanwhile, were associated with greater long-run relative accumulations of buffer livestock by farms under 15 acres in worse affected districts, in tandem with no long-run relative reduction in acreage allocation to the potato in more demographically dense districts and, indeed, a long-run relative reallocation toward the potato crop in districts with higher pre-famine valuations.

As in Chaps. 2 and 3, results furthermore suggest further research is needed to explore markets for livestock assets during the famine. Estimated coefficients reported in Tables 5.3, 5.4, 5.5, and 5.6 consistently show opposite signs for changes in livestock holdings among farms under 15 acres versus over 15 acres in worse affected districts. In particular, I observe that relative liquidations or accumulations of specific livestock assets by farms under 15 acres are generally accompanied by relative accumulations or liquidations, respectively, of the same livestock asset classes by farms over 15 acres in more severely infected districts. This suggests that sales of such assets by farm enterprises of different scales may have been important mechanisms of adjustment in both the short and long runs.

6

The Great Famine in the Short and Long Run

> Sir, I am in receipt of your letter of the 21st August on the subject of the disease in the potato crop and I am sorry to have to inform you, in reply, that I am of opinion that fully one third of the potato's in this district are quite unfit for human food. I have had frequent opportunities of examining them in different parts of the country for the distance of about 7 or 8 miles round here. – Report of Patrick Martin, Office of Public Works, on the state of the potato crop in Leitrim, County Galway, 25 November 1845

The Great Famine was a devastating event that had profound and persistent effects on Irish population and agriculture. Initial short- to medium-run responses to blight, in the form of greater accumulations of buffer livestock assets and demographic decline, were eventually superseded in the medium and long runs by changes in land use, namely, substitutions away from the potato toward other tillage crops and pasture. Thus, while proto capital markets and labor were much more flexible in the short and medium runs, land was for the most part initially fixed, with fundamental changes in land use only occurring over the long run. Access to microcredit from the Irish Loan Funds was

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an important factor in enabling non-demographic adjustment to the adverse environmental shock.

In the short to medium run, districts that were severely or considerably afflicted by blight in the first two years (7004 and 4699 people) of the famine experienced 17.3 % and 13.0 % larger population declines (corresponding to 7,004 and 4,699 more deaths or emigrations) by 1851 than moderately affected regions, with consistent gaps of 17.2 % and 13.2 % (7,859 and 5,003 persons) persisting even 40 years after the end of the famine. By the end of the famine, the fraction of all farmholdings under 1 acre had declined by 8.2 percentage points more in worse affected Poor Law Unions. Blight furthermore immediately affected patterns of livestock holding. In the short run, relative to small farms of up to 15 acres in moderately impacted baronies, small farms in baronies suffering severe or considerable blight infection in 1845 and 1846 significantly increased stocks of chickens and pigs—traditional income buffers in the event of crop failure—while the largest farms (over 30 acres) experienced no systematically different changes in livestock holdings, and medium- to large-sized farms (15 to 30 acres) may even have reduced swine and poultry stocks. In value terms, by 1850, small farms of up to 15 acres in severely and considerably infected baronies had increased buffer stocks of poultry and swine by £388.59 and £302.02 more, respectively than small farms of up to 15 acres in only moderately infected baronies.

In the medium and long runs, however, worse affected baronies effected larger substitutions toward other tillage crops and grazing livestock. Relative to lesser impacted areas, districts that were worse affected by blight substantially and permanently converted acreage under potato cultivation to other crops, though did so only after two successive crop failures. While PLUs suffering medium- to-high-blight infection only increased the fraction of total tillage acreage allocated to other crops in 1846 by 1.6 percentage points more than lesser affected PLUs, by 1847 PLUs that had suffered higher infection rates in the preceding two years increased the non-potato share of total crop acreage by 10.7 percentage points more than lesser impacted PLUs. In the long run, worse affected PLUs are estimated to have effected a permanent 11-percentage point relative reduction in the potato's share of total crop acreage. Long-run acreage reallocation to pasture by medium-sized farms was also significant; by 1871, farms of 5 to 15 acres in severely affected baronies had increased

cattle stocks by 74.7 percentage points more than 5–15 acre farms in moderately affected baronies, while farms of 15 to 30 acres in severely affected baronies increased sheep holdings by 151.7 percentage points more than 15–30 acre farms in moderately affected baronies.

Microfinance credit from the Irish Loan Funds played a significant role in non-demographic adjustment to blight. Relative to moderately affected baronies, severely affected baronies with at least one active Loan Fund during the famine years experienced 42.1 % smaller population declines, corresponding to 3,661 fewer deaths and emigrations, by 1851 (corresponding to 7,669 fewer deaths and emigrations) than severely impacted baronies without. Loan Fund lending in severely affected districts during the famine was associated with larger and earlier substitutions toward other tillage crops and increases in temporary buffer stocks of pigs and poultry than in severely affected districts with less or no lending. Specifically, during the famine, relative to low-medium-impact PLUs, medium- to-high impact PLUs with a Loan Fund increased the fraction of total tillage acreage under other crops by 54.6 percentage points more by 1847 than medium-high-impact PLUs without. By the end of the famine, the relative decrease in the potato's share of total crop acreage was 34.3 percentage points greater in medium-high-impact PLUs with a Loan Fund versus in those without.

Finally, during and immediately after the famine, small- to medium-sized farms in severely infected baronies with a Loan Fund experienced significant relative increases in holdings of buffer stocks of pigs and poultry; by 1852, farms of 1 to 5 acres in severely infected baronies with a Loan Fund had increased stocks of pigs and chickens relative to moderately infected baronies by 133.3 and 82.3 percentage points more, respectively, than farms of 1 to 5 acres in severely impacted baronies without a fund. Also by 1852, relative to small- to medium-sized farms in moderately infected baronies, small- to medium-sized farms of 5 to 15 acres in severely and considerably infected baronies with a Loan Fund had increased holdings of cattle by 31.1 and 28.5 percentage points, respectively, than 5–15-acre farms in severely and considerably infected baronies without a fund. Loan Funds do not appear to have had any effect on differential relative changes in livestock holdings by farms larger than 15 acres. All estimates are robust to analysis by two-stage least squares regression, using an instrumental variable strategythat exploits the unique historical origins of these funds.

Results presented in Chap. 5 furthermore indicate that the statistical record is generally inconsistent with a predominantly Malthusian account of the Irish Famine. That is, controlling for the severity of blight infection, access to microfinance credit, regional-time fixed effects, and spatial fixed effects, while higher adult literacy was associated with smaller relative population declines in worse affected districts, other traditional "Malthusian" variables do not appear to have been associated with differential demographic changes in worse affected districts, relative to less severely affected districts. Specifically, the cumulative population decline, relative to low-blight baronies, was still statistically no different in high- and medium-blight baronies with higher pre-famine population density, potato dependence, baronial valuations, and fourth-class housing stock versus high- and medium-blight baronies with lower pre-famine population density, potato dependence, baronial valuations, and fourth-class housing stock.

Results do, however, suggest that variation in pre-famine Malthusian pressures was associated with differential relative adjustments in land use and livestock acquisition and disposal, particularly over the medium to long runs. While greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were associated, in the short run, with greater acreage allocation toward the potato in worse affected districts, over the medium and long runs, worse affected districts with higher pre-famine potato dependence and fourth-class housing substituted crop acreage away from potato cultivation. Specifically, after the first year of blight, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively increased the fraction of tillage acreage allocated to the potato crop by 0.014 and 0.017 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation. By 1856, however, high- and medium-blight baronies with pre-famine crop acreage allocation to the potato greater by 1 percentage point relatively reduced the fraction of tillage acreage allocated to the potato crop by 0.038 percentage points more than high- and medium-blight baronies with a 1-percentage point lower potato crop acreage allocation.

Similarly, after the first year of blight, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively increased the fraction of tillage acreage allocated to the potato crop by 0.007 and 0.006 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing. By 1856, however, high- and medium-blight baronies with houses rated fourth class accounting for a 1-percentage point greater share of total housing stock relatively reduced the fraction of tillage acreage allocated to the potato crop by 0.011 and 0.014 percentage points more, respectively, than high- and medium-blight baronies with a 1-percentage point lower fourth-class share of total housing.

Parallel to adjustments in crop acreage allocation, greater pre-famine reliance on the potato crop and higher concentration of fourth-class housing were also associated with differential changes in livestock assets among farms under 15 acres in worse affected districts. In the short through medium runs, farms under 15 acres in worse affected districts with higher pre-famine potato dependence and fourth-class housing stock, relative to equivalently sized farms in low-blight districts, increased stocks of buffer livestock holdings of chickens and pigs, compared to farms under 15 acres in worse affected districts with lower potato dependence and fourth-class housing stock. These relative accumulations, however, dissipated over the very long run. Greater pre-famine potato dependence and fourth-class housing stock were, moreover, associated with greater short-run liquidations of grazing livestock assets by farms under 15 acres in worse affected districts. Higher pre-famine population density and valuations, meanwhile, were associated with greater long-run relative accumulations of buffer livestock by farms under 15 acres in worse affected districts, in tandem with no long-run relative reduction in acreage allocation to the potato in more demographically dense districts and, indeed, a long-run relative reallocation toward the potato crop in districts with higher pre-famine valuations.

The results of this study therefore suggest that access to microfinance plays a significant role in short- and medium-run non-demographic adjustment to adverse environmental shocks in a subsistence or near-subsistence

economy. Longer-run, non-demographic adaptations to the arrival of blight in Ireland—specifically, relative crop portfolio diversification and substitutions away from tillage toward pasture—were effected earlier and to a greater extent in worse affected districts with a microfinance lender versus in those without. Moreover, access to microcredit appears to have allowed farmers to acquire stocks of relatively cheap liquid buffer livestock assets with low, but also low volatility, yields.

In particular, the relative accumulation of stocks of poultry and swine by small farms in worse affected districts with a microfinance fund versus in those without suggests that the importance of certain types of buffer livestock may largely reside in their ability to provide a relatively cheap hedge against adverse harvest shocks by yielding a low but relatively reliable supplemental income stream, for example, through the sale of eggs from poultry stocks. This contrasts with more conventional buffer stock models, which emphasize liquidation value. Future research should perhaps therefore focus somewhat less attention on changes in net livestock sales in response to adverse production shocks, and somewhat more attention on changes in the contribution of net revenues from different types of livestock production to total household net revenue. Microfinance appears, however, to have had a limited effect on economic adjustment by the smallest farmers, which suggests that other forms of relief may be necessary to mitigate the effects of adverse environmental change on the most vulnerable populations.

The results of this chapter do not challenge more traditional explanations of the Great Famine which emphasize the importance of social and institutional variables in explaining the spatial spread of famine intensity (McGregor 1984; Ó Gráda 1999). Rather, controlling for such variables as best as possible with both observable regressors and spatial and time fixed effects, I demonstrate, first, how marginal adjustments differed where the environmental shock was marginally more severe; and, second, how relative marginal adjustments differed where, controlling for the severity of the environmental shock, one binding constraint was partially relaxed. Analyzing a shock of the magnitude of the Great Famine allows the econometrician to observe such relative marginal adjustments as may not be observable in studies of less severe environmental events.

Building on Hornbeck (2012), which focuses on margins of adjustment in a more developed economy context and does not explore the possible effects of constrained credit on the time-path of adjustment in great depth, the results of this study demonstrate that access to credit plays an important role in short- and medium-run adjustment to adverse environmental shocks in a subsistence economy. The long-run non-demographic adaptations to the arrival of blight in Ireland, specifically crop portfolio diversification and substitutions away from tillage toward pasture, were effected earlier and to a greater extent in worse affected districts with a microcredit lender versus in those without. Moreover, in the presence of incomplete capital markets, access to microcredit appears to have allowed farmers to acquire temporary stocks of relatively cheap, liquid buffer livestock assets with low, but also low volatility, yields. This is significant because while recent research has demonstrated that access to microfinance credit can mitigate the impact of environmental shocks on income and consumption (Dercon 2002), most microfinance studies have focused on welfare effects and optimal models of sustainability under relatively ordinary lending circumstances.

Second, this study contributes to the extant literature on the debated role of livestock in smoothing consumption in developing contexts. While Rosenzweig and Wolpin (1993) and Verpoorten (2009) provide evidence for the use of bullocks by credit-constrained households in rural India and Rwanda as buffer stocks for consumption, Fafchamps et al. (1998) find that livestock sales in Burkina Faso compensated for only 30 % of income shortfalls due to adverse rainfall shocks, and Kazianga and Udry (2006) find little evidence of consumption smoothing. The results of this study, however, suggest that in analyzing the role of buffer livestock in consumption smoothing, it is important to distinguish between different types of livestock and their purpose for different types of farmers. Moreover, results indicate that the importance of buffer livestock may lie not so much in their liquidation value in the event of income shortfalls, as is typically reckoned, but rather in the hedging value of a low but relatively reliable supplemental income stream, for example, with the sale of eggs from poultry stocks.

Lastly, since the results presented in Chaps. 2 and 3 indicate that substitutions away from the potato, a highly non-tradeable good, toward the production of more tradeable goods—wheat, oats, eggs, pork, butter, and beef—constituted a critical margin of adjustment, further research is needed to elucidate the linkages between local, national, and international markets during the famine. Specifically, short-run relative accumulations of buffer livestock by smaller Irish farms simultaneously with possible relative drawdowns of such stocks by larger farms, as well as longer-run relative substitutions toward cattle by medium-sized farms simultaneously with relative substitutions toward sheep by larger farms, point toward the potential role of markets for livestock assets among farms of different scales in smoothing adjustment to adverse production shocks. Results presented in Chap. 5 furthermore show opposite signs for changes in livestock holdings among farms under 15 acres versus over 15 acres in worse affected districts with high pre-famine population density, potato dependence, valuations, and concentrations of fourth-class housing stock. In particular, I observe that relative liquidations or accumulations of specific livestock assets by farms under 15 acres are generally accompanied by relative accumulations or liquidations, respectively, of the same livestock asset classes by farms over 15 acres in more severely infected districts. Limited evidence of relative changes in average farm size similarly indicates that further research is needed to elucidate markets for land during and after the famine, and in particular the mechanisms of land transfer from smaller to larger farms, and possibly related changes in population and agricultural labor force structure.

I also find, in Chap. 4, that a large environmental shock can have significant adverse effects on MFI sustainability, resulting in lower institutional survival probabilities, large declines in lending, capital levels, and numbers of depositors, as well as substantial flight to quality in lending portfolios. During the Great Famine, borrowing costs for qualifying borrowers in worse affected districts therefore actually fell as funds in these districts contracted lending and significantly raised credit standards. I further find that pre-famine balance sheet data were important predictors of MFI survival during the famine, though certain metrics that were generally associated with higher (lower) survival probabilities were associated with lower (higher) survival probabilities where the magnitude

of the environmental shock was greater. While greater leverage, lower average staff salaries, and more depositors were generally associated with higher predicted probabilities of institutional survival, the reverse was true where blight infection was more severe. Conversely, though funds with higher gross profit margins per loan before the famine were generally no more likely to succeed over the long run than less profitable funds, higher pre-famine margins were strong positive predictors of institutional survival where blight infection was worse.

Differences in pre-famine balance sheet metrics were also associated with differential institutional responses to the adverse shock. Relative to funds with lower average gross profit margins per loan before the famine, funds in worse affected districts with higher pre-famine margins relatively reduced average loan size, interest rates, fines ratios, and bad debts during the famine, indicating a relative increase in average credit quality among approved borrowers. Funds in worse affected districts with more highly remunerated staff before the famine similarly relatively reduced their mean annual number of loans and fines ratios during the famine. However, though funds with higher pre-famine margins experienced relative declines in average margin per loan, there was no relative difference in their average, non-differenced level of profit margin per loan during the famine. In contrast, funds in severely infected districts with more depositors before the famine experienced relative increases in average loan size, fines ratios, and bad debts during the famine, while funds in worse affected districts that had been more highly levered before the famine experienced a relative rise in the average unit cost of credit intermediation and relative decline in profitability, resulting in a lower average gross profit margin per loan during the famine.

This study therefore not only reaffirms the tension between sustainability and outreach in microfinance, but also reveals that optimal MFI lending models under ordinary circumstances may impede adjustment to a major aggregate shock. Specifically, results show that MFI sustainability in the face of a major spatially correlated shock depends critically on an ability to rapidly scale down lending, reduce average loan size, and significantly raise lending standards, and therefore that though microfinance may mitigate the effects of such shocks on borrowers of higher credit quality, it is not a viable mitigant for more vulnerable, marginal borrowers. This

is consistent with Goodspeed (2016a) and Chapter 3, above, where I find that while access to Loan Fund credit had significant effects on relative accumulations of buffer livestock during the Great Famine by midsized farms of 5 to 15 acres, it had limited effects on relative changes in livestock holdings by farms of fewer than 5 acres.

Moreover, whereas a broader depositor base was ordinarily advantageous to institutional sustainability, the additional liability of more depositors appears to have limited funds' capacity to contract lending portfolios and raise average credit standards in response to adverse shock. Similarly, though greater leverage was generally a strong positive predictor of long-run MFI survival, where the magnitude of the environmental shock was greater, funds that had been more highly levered were less able to effect balance sheet contraction while remaining profitable. In contrast, Loan Funds that had been earning higher rents before the famine appear to have had more scope to contract lending and raise credit standards while still remaining profitable. Meanwhile, higher paid staff, though ordinarily a long-run institutional liability, were more effective in restricting credit to higher-quality borrowers in response to worse blight infection.

The Great Famine of Ireland was a rare event that allows for an analysis of differential MFI outcomes and adjustment strategies to a major aggregate shock, over both the short and long runs. Further research is needed, however, to better understand the causes of variation in pre-famine MFI balance sheets and to evaluate the potential private and social welfare costs under ordinary conditions of greater institutional resilience to rare adverse environmental events. Moreover, while the empirical design of this study allows for the estimation of the marginal effects of access to small-loan credit, marginal analysis may miss significant inframarginal effects of credit on differential outcomes, and in particular the effects on smaller-scale, more vulnerable farmers of relatively larger-scale, less vulnerable farmers retaining access to credit in the face of adverse shocks. There is, therefore, considerable scope for future research into estimating the general equilibrium effects of the Great Famine.

References

Primary

Blight Severity: Blight severity in 1845 and 1846 is obtained from the famine Relief Commission Papers, 1845–1847. RFLC3/2, Incoming Letters: Baronial Sub-series. The National Archives of Ireland, Dublin Ireland. Observations made at the civil parish, township, or PLU level are assigned to their corresponding baronies.

Population: Population data are from the decennial *Census of Ireland*, 1821–1891. After 1891, data are no longer available at the baronial level. For full documentation and digitized data, see Clarkson, L.A. et al., *Database of Irish Historical Statistics: Population, 1821–1911* [computer file]. Colchester, Essex: UK Data Archive [distributor], November 1997. SN: 3578, http://dx.doi.org/10.5255/UKDA-SN-3578-1.

Loan Funds: Data on Loan Fund activity are from the annual reports of the Loan Fund Board of Ireland, 1843–1851, compiled by Aidan Hollis and Arthur Sweetman (see Hollis and Sweetman 1998, 2001, 2004). Association of Irish Musical Societies member societies are assigned to the barony in which they are based.

Agricultural Data: Livestock and baronial-level crop data are from *Returns of Agricultural Produce in Ireland* (1847–1856) and *Agricultural Statistics of Ireland* (1857–1871). Potato crop acreages for 1844–1846 are from tabulated

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constabulary returns in the Public Record Office of Ireland assembled by Austin Bourke (see Bourke 1960, 1965b). Subsequent crop acreage data are from *Returns of Agricultural Produce in Ireland* (1847–1856) and *Agricultural Statistics of Ireland* (1857–1871). For full documentation and digitized data for post-1847, see Clarkson, L.A. et al., *Database of Irish Historical Statistics: Agricultural Statistics Crops and Stocks, 1847–1911* [computer file]. Colchester, Essex: UK Data Archive [distributor], November 1997. SN: 3575, http://dx.doi.org/10.5255/UKDA-SN-3575-1. Landholding data at the Poor Law Union level is from the 1845 *Appendix to the Minutes of Evidence taken before Her Majesty's Commissioners of Inquiry into the State of the Law and Practice in Respect to the Occupation of Land in Ireland. Minutes of Evidence* were the official report of the Devon Commission appointed by the government of Sir Robert Peel to research landholding in Ireland. The commission was headed William Courtney, the 10th Earl of Devon. 1879 Potato yield data for 1879 is from the preliminary Parliamentary report of the 1879 *Returns of Agricultural Produce in Ireland*. Livestock prices are compiled from Alexander Thom's *Statistics of Ireland*, from *Thom's Irish Almanac and Official Directory*, an annual almanac of Irish statistics.

Control Variables: Adult literacy and fourth-class housing share at the baronial level and barony and PLU area in statute acres are taken from the 1841 *Census of Ireland*. Pre-Famine baronial and PLU valuations are from partial returns from Griffith's *Valuation of Ireland*, which was commissioned by the British government in preparation for the first Ordnance Survey, and Her Majesty's Poor Law Commissioners, as collected by Poor Law administrators in Ireland and presented in the 1845 *Appendix to the Minutes of Evidence taken before Her Majesty's Commissioners of Inquiry into the State of the Law and Practice in Respect to the Occupation of Land in Ireland*.

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